

The Disasters in Japan 2011

Kamedo Report 98

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This publication is an English translation of Kamedo report #98, written in Swedish and initially published in December 2013. Since then, a number of extensive and important international assessments, "lessons learned", have been performed related to the disasters in Japan 2011, in particular to the Fukushima Daiichi power plant accident. Major examples include reports from the IAEA¹, the WHO², the UNSCEAR³ and the ICRP⁴. The Kamedo report #98 focused on how to improve the national Swedish preparedness capability to manage disasters in general, radiological disasters in particular. In the Discussion chapter a number of measures were proposed. As by March 2016 a number of steps and actions have been carried out, while others are in progress, to meet these demands. Some examples:

- Authorities and other actors within the preparedness system are increasingly aware of the importance of regular exercises for maintaining a high level of preparedness, and in various ways support these. A Swedish CBRNE strategy was recently published, developed by the authorities with a responsibility for preparedness regarding hazardous materials. One of the main focus areas pointed out in the CBRNE strategy is regular exercises as well as education of experts and key individuals in the preparedness system.
- The Swedish Radiation Safety Authority has been commissioned by the government to present a revision of the emergency zones and planning distances around nuclear power plants in Sweden, which will be presented during the spring 2016⁵. Revised emergency zones and planning distances will enable the county councils and municipalities to better plan and prepare for medical evacuation, balancing benefits of dose reductions against the risks involved with evacuation of vulnerable groups such as critically ill patients in hospitals, elderly, children and special care facilities.
- A new regulation⁶ issued by the Swedish Radiation Safety Authority requiring licensees of NPPs to provide an emergency response organization capable of dealing with simultaneous emergencies at all reactor units at the site over a minimum period of one week has been implemented.
- The National Board of Health and Welfare recently published a review, commissioned by the government, of trauma care and preparedness within the health care system in Sweden⁷. Tasked to provide strategic input, one of the proposals of the report was to establish a trauma care system including three levels of care; National Trauma Centres, Regional Trauma Units

1 The Fukushima Daiichi accident. Report by the Director General. IAEA Publication 1710, 2015.

2 Health risk assessment from the nuclear accident after the 2011 Great East Japan earthquake and tsunami, based on a preliminary dose estimation. World Health Organization 2013 ISBN 978 92 4 150513 0

3 United Nations Scientific Committee on the Effects of Atomic Radiation, 2013 report: Levels and effects of radiation exposure due to the nuclear accident after the 2011 great east-Japan earthquake and tsunami.

4 Report of ICRP Task Group 84 on initial lessons learned from the nuclear power plant accident in Japan vis-à-vis the ICRP System of radiological protection. International Commission on Radiological Protection ref 4832-8604-9553 2012 November.

5 Uppdrag om översyn av beredskapszoner. Government commission to the Swedish Radiation Safety Authority (dnr M2015/03597/Ke), to be presented 1 April 2017.

6 Strålsäkerhetsmyndighetens föreskrifter om beredskap vid kärntekniska anläggningar (SSMFS 2014:2). Strålsäkerhetsmyndigheten; 2014.

7 Traumavård vid allvarlig händelse. Socialstyrelsen; 2015

and pre-hospital acute care with transportation medicine. Well supported professional networks and standardized service requirements would be necessary pre-requisites for achieving high quality trauma care. For maintaining the ability of such a system systematic evaluation, research, education, training and exercise will all be essential aspects.

- The ability to receive aid may be a key issue in the aftermath of a disaster. The Swedish Civil Contingencies Agency has recently published guidelines for host nation support (HNS)⁸. These are currently being implemented by the various actors within the preparedness system in Sweden.
- The Centre for Research on Health Care in Disasters at Karolinska Institutet has, in collaboration with the WHO, been instrumental in developing standards for Emergency Medical Teams (EMT)⁹. Planning for further implementation in Sweden is in progress. The Swedish Radiation Emergency Medicine Centre, also at Karolinska Institutet, has through the EBMT¹⁰ been involved with developing standards for advanced hospital units treating radiation victims. Both of these efforts, have been supported by the National Board of Health and Welfare, and should strengthen the ability to receive, as well as to provide, international aid.

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⁸ Vägledning i att ta emot internationellt stöd. Myndigheten för samhällsskydd och beredskap; 2015.

⁹ Classification and minimum standards for Foreign Medical Teams in sudden onset disasters. WHO; 2013.

¹⁰ The European Blood and Marrow Transplantation group.

Preface

On March 11, 2011 an earthquake occurred in the ocean off the coast of Japan. It spawned a tsunami which struck the nearby parts of the Japanese coast and caused massive destruction, including the nuclear accident at Fukushima which has subsequently been reclassified to 7 on the INES scale. The disaster involved multiple incidents that affected a society with well-developed infrastructure and good access to resources and, in terms of resources, the Japanese society can in many ways be compared to the Swedish society. There is much Sweden can learn from the handling of the disaster both regarding the general aspects of how healthcare initiatives worked, as well as specific problems particularly in connection with the nuclear accident.

In order to gather knowledge, the National Board of Health and Welfare together with the Radiation Safety Authority and the Swedish Civil Contingencies Agency, carried out an observer trip to Japan in September 2012 to study the Japanese experiences from the management of the triple disaster, especially from a medical perspective. In parallel to this, a similar trip was made by the Swedish Civil Contingencies Agency, the Swedish Board of Agriculture and the County Administrative Boards of Kalmar, Halland and Uppsala to study the decontamination work following the nuclear accident which will provide a separate report.

The Kamedo report highlights both general disaster medical aspects related to the impact of the earthquake and tsunami, and more specifically radiation emergency medical aspects associated with the nuclear accident. The report is aimed primarily at those working with emergency preparedness planning and emergency management in the healthcare and social services sectors, but it can also serve as valuable input to other operatives covering other areas of responsibility. Lessons from the report can also be used at the National Board of Health and Welfare and other operators in their work on risk and vulnerability analysis (RSA) as well as with the priorities associated with operational planning for combating and preventing the identified deficiencies. This report has been produced with funding from the grant 2:4 Emergency Preparedness.

The National Board of Health and Welfare would like to express special thanks to Growth Analysis's local offices in Tokyo, as well as to the Embassy of Sweden in Tokyo, without which the observer initiative could not have been implemented. The National Board of Health and Welfare would also like to thank all the authorities, organisations, individual experts and those on site who have been impacted that have generously shared their valuable experiences and knowledge.

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- Fire and Disaster Management Agency, Civil Protection and Disaster Management Department
- The Fukushima Prefectural Government
 - Contingency Preparedness Planning
 - Nuclear Power Safety
 - Local Medical Care Division
 - Food Safety
 - Decontamination
 - Recovery Measures Farms and Forestry Unit
- Tohoku Medical Mega Bank
- Tokyo Medical and Dental University
- DMATs deployed to the affected areas, physicians to the Nuclear Emer-

gency Response HQ and helped with the screening of accomodation in the Fukushima area who made occasional visits to the vacated sites.

- Fukushima Medical University
- Fukushima Red Cross Hospital
- Ishinomaki Red Cross Hospital
- US Embassy in Tokyo
- NGO “It's Not Just Mud” and a delegation of residents in temporary emergency housing
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The University of Tokyo. Worked on his own initiative with the screening of the general public in Minami Soma City General Hospital. Minami Soma is located 23 kilometres from the nuclear plant.
- Growth Analysis Tokyo office, especially Dr. Anders Karlsson, Dr. Niklas Kviselius, Ms. Kaoru Tomihisa and Dr. Setsuko Hashimoto.
- The Embassy of Sweden in Tokyo

Summary

Summary

On March 11, 2011 at 14:46 the north-eastern part of Japan was hit by an earthquake with a magnitude of 9.0. The epicentre of the earthquake was in the ocean about 130 kilometres east of the coast and was the most powerful quake ever to hit Japan. The earthquake triggered a powerful tsunami that reached the East Coast 26 minutes after the earthquake. Despite high protection barriers in several places along the coast, the tsunami swept in, and in the Sendai prefecture the water reached 10 km inland in some places. It was primarily the tsunami that caused damage to property. The earthquake and tsunami contributed to the breakdown of the nuclear power plant at Fukushima Dai-ichi. Extensive parts of the infrastructure were eliminated in whole or in part in several prefectures which severely hampered rescue efforts. Great parts of Japanese society were affected and became involved in the subsequent clean-up work caused by the triple disaster from both an acute and a long term perspective. The breakdown of the nuclear power plant alone would have been a disaster of such a magnitude to be challenging for the authorities and for the response staff to handle. It resulted in a situation where the Japanese authorities needed to ensure and coordinate rescue and relief efforts following the earthquake and tsunami over wide spread areas where infrastructure had been wiped out completely or partially – in particular the means of communication – while some of the response staff were also among the victims. Relocating and housing victims whose homes had been destroyed, and the offers of assistance from the rest of the world were among the major issues to deal with. Maintaining ongoing and coordinated communications with the media, the general public and the outside world posed a challenge that was difficult to surmount.

Experiences

There is a lot that other countries can learn from how Japanese society handled the triple disaster of 2011. A number of lessons observed and conclusions that can be drawn in terms of Swedish preparedness from the perspectives of the report are presented below.

The safety situation and responses for Swedes living abroad

The risk of radionuclear incidents occurring in the world made itself evident in the context of the nuclear power accident in Japan in 2011. The Swedish medical expertise on preparedness and management of these incidents should be strengthened, including the Swedish Response Team.

Planning for major incidents

Protecting society from serious incidents that occur very rarely requires trade-offs between risks and costs, and what society should invest in. This is particularly evident in a Swedish context, where we are rarely subject to

major disasters. How prepared should society be, and what will it cost? Swedish emergency preparedness also needs to improve its ability to cope with multiple, simultaneous incidents. The combination of disasters that occurred in Japan is unlikely in Sweden. However, there may be other combinations that could cause equivalent problems but may be difficult to identify. Stress testing of society's emergency preparedness measures could then be a good tool in identifying any weaknesses.

The nuclear disaster in Japan shows that such accidents can lead to an extended crisis where the emergency situation continues for weeks or even months or years. This in turn leads to significant pressure on the organisations that are handling the accident and its consequences. Organisations with responsibilities in nuclear energy preparedness therefore need to develop plans for managing protracted sequences of events.

The disaster medical planning needs to take into account that different disasters create different acute medical needs, but that chronic conditions among the population will continue to need to be taken care of with perhaps partially eliminated infrastructure. This means that the greatest needs after a disaster are not necessarily those created by the direct effects of the disaster itself but rather the indirect effects caused by health service infrastructure destruction leading to reduced health service coverage. To mitigate such effects disaster medicine skills are required

Medical evacuation

It is a major challenge to evacuate people effectively and safely from hospitals and nursing homes. Clearly defined and elaborate plans are necessary that must also involve training. This is especially relevant for evacuations involving vulnerable groups, such as critically ill patients in hospitals, children, the elderly and individuals requiring special care in nursing homes, etc. The experiences from Fukushima underline the importance of making well balanced risk-benefit analyses of an evacuation, i.e. carefully weighing the risks involved in a fast evacuation of specific groups of the population (as described above), against reduced exposure to radiation and thereby reduced long-term health hazards that an evacuation can entail.

Exercises

Exercises must be conducted so that they are perceived as relevant by the participants. It is important to focus the exercises to hone the particular practical skills that may be required, such as in a nuclear accident. A special aspect about exercises for healthcare professionals concerns taking into consideration the risk of the fear of staff being injured in connection with the handling of suspected or actually contaminated patients following radio-nuclear incidents. In the context of Fukushima, as with many completed exercises, examples of intense fear of radiation were noted that led to the risk of seriously late or no medical management at all for patients with intensive care needs. This problem should be addressed more clearly in future planning.

Medical reinforcement resources

The ability to quickly mobilise materials for medical staff for response efforts in disaster hit areas could be an important disaster medical resource in

well-defined contexts. However, this requires clearly defined roles and management as well as regular exercises. The value of such a resource must be weighed against the costs.

Reinforcement resources – radiation medicine

Classification into primary, secondary and tertiary hospitals would be of great value to Sweden. This would provide the opportunity to practice and maintain skills at each level. Hospitals that may be expected to take of contaminated or suspected contaminated patients need to invest in continuous training and exercises for their staff. The goals for activities should also include help in reducing the fear of radiation. In the face of rare but potentially devastating disasters, international medical preparedness collaboration is of major importance – which particularly applies to radionuclear incidents. Sweden is already involved in various international collaborations but these can be further developed and concretised.

Receiving assistance

In connection with major disasters, it is not uncommon for other countries to offer to send reinforcement resources. It is important that the affected country clearly indicates the types of needs that have to be covered along with the conditions under which the resources can be received in order for these resources to be useful. Receiving resources that are not essential can drain the energy and assets that are needed for other tasks.

Volunteers

It is important that there is a plan that takes into account voluntary initiatives and that there are procedures in place to receive contributions from private individuals and NGOs.

Communication – alarms and technology

Communication is often a problem in disaster areas. The response team must be able to work independently along a given direction, without continuous communication. Other tools, such as Rakel (the Swedish national TETRA-based digital communications system) or satellite telephones, are available and can be used by everyone involved in the rescue efforts.

Communication with the general public and media

Quick and proactive communication with the general public is a key factor and may mean the difference between trust and lack thereof. If the authorities do not inform, citizens will seek information from other sources. A clear communication plan must be in place for how to communicate with the general public and the media through traditional and social media. Preparations must be in place for access to skilled spokespersons.

The nuclear disaster in Japan shows that lack of knowledge about radiation and its risks gives rise to fear. The accident also shows that it is difficult to try to put the radiation risks into a context when the accident has already happened. Basic training about radiation should be included in regular school curricula at both primary and secondary level. Residents near nuclear power facilities should also receive additional information since they may be affected most if an accident should occur. Knowledge regarding the medical

effects and treatment of acute radiation incidents is also inadequate in Swedish healthcare. Training initiatives are therefore primarily needed in emergency care and medical units that provide direct care responsibility for patients affected by radiation.

Restoration and Follow-up Work

It is very important to have good co-operation and dialogue between government authorities and all others concerned regarding constructing living accommodation, awarding compensation for loss of income etc. Otherwise there is the risk of individual participants making promises which at a later stage cannot be fulfilled.

Aims, Materials and Method

The triple disaster – consisting of the earthquake, tsunami and subsequent nuclear accident – was so widespread that it affected virtually all of Japanese society. It is unusual for Sweden to be hit by such large disasters or emergencies, and it is therefore important that Sweden learns from the experiences of other countries in order to strengthen and develop the Swedish emergency management system.

Aims

The report aims to strengthen Swedish emergency preparedness by compiling and presenting in an easily accessible way the incidents and the experiences made by the Japanese society in the handling of the triple disaster. One purpose is to discuss how the Japanese experiences can be used in Swedish conditions and how this could help to strengthen Swedish emergency preparedness.

The report describes the sequence of events, injuries and disruptions, and compiles a list of actions and experiences. The lessons that can be learned for Swedish preparedness are discussed. This report does not purport to describe the full range of consequences, or how they are managed. Neither does the report describe the actions of the Swedish authorities in connection with the disaster, whether on site in Japan or in Sweden. The focus is mainly on Japanese healthcare and nursing as well as some emergency services management at local, regional and national levels. Another area of focus is the specific management in connection with the nuclear accident. To put these issues in context, the report briefly describes the efforts of some other operators.

The report is written to be read even without in-depth knowledge in the subject area. Its purpose is to reach a broad target audience comprising decision makers, officials and operational providers within the Swedish emergency management system.

Materials and Methods

This is a retrospective study the primary aim of which is to compile the experiences of the three disasters, focusing on what the Swedish emergency preparedness system can learn. The study is based on data collection using several different methods.

Secondary Data

The study included a variety of secondary data that was collected by the authors, mainly through Internet searches on sites like PubMed and Google Scholar with keywords such as “Japan”, “tsunami” and “Fukushima”. Articles that were considered relevant to the report have been identified and processed. The authors of the report have read the articles and extracted information and data from them and from other identified literature. Second-

ary data has also been generated from studies and reports published by various Japanese and international bodies. The collection of data continued up until May 2013.

Interviews with Key Informants

Prior to the observational trip, the authors formulated a number of questions focusing on the reactions of authorities and actions in connection with the three disasters. Representatives from Growth Analysis in Tokyo are also the Swedish Embassy's technical attachés. They were part of the Embassy's emergency team in 2011 and helped to identify key individuals with personal or professional experience from the disasters. These key individuals worked with the relevant authorities, hospitals and institutes or have special knowledge in the subject. Some are representatives of the affected population. The key individuals provided information and were interviewed at meetings held in Tokyo, Fukushima, Sendai and in the tsunami-affected area. These people had received translated questions in advance from the authors and had focused their presentations on these. After the meeting the authors who travelled asked supplementary questions.

Observation

The authors spent five working days in Japan (see itinerary). The group travelled throughout the most affected areas and visited the institutions and authorities that have been involved in the disaster and its management at a central, regional and local level.

Analysis and Conclusions

The authors of the report have compiled the collected data and information based on their expert knowledge and their own professional experience and discussions within the group. The collected material was compared with studies and experiences from similar disasters. The main points of the report were discussed and analysed over two full days at the National Board of Health and Welfare, and through other forums. Based on this, the authors present a number of conclusions and observations that they consider relevant for the Swedish emergency preparedness system to learn from.

Background

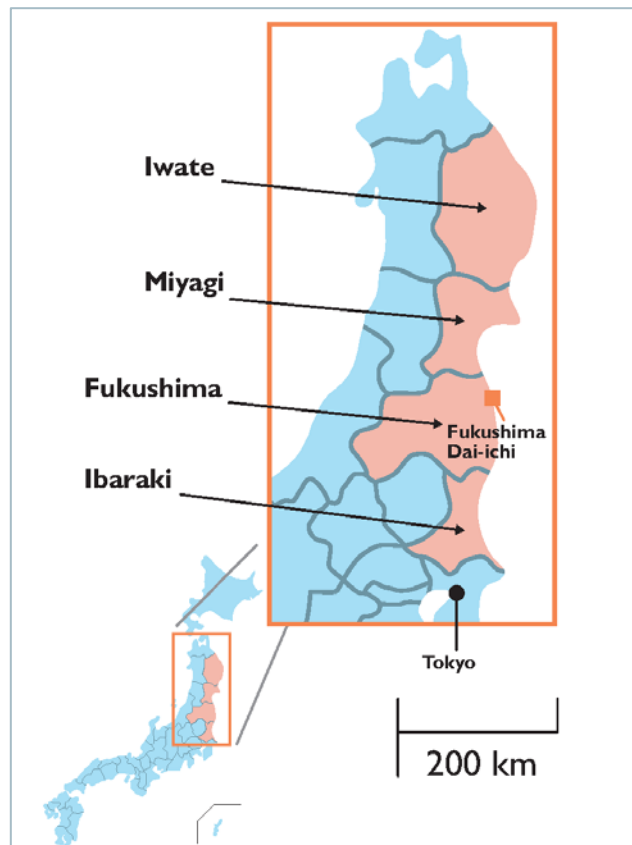
Japan is slightly larger than Finland in area and consists of four major islands (Hokkaido, Honshu, Shikoku and Kyushu) and numerous smaller ones. The country has just over 128 million inhabitants. Japan is situated where several tectonic plates meet and therefore often suffers from earthquakes, the majority of which do not cause any harm to the population or infrastructure.

Power in Japan is divided between the country's democratically elected parliament (legislative), the government (executive) and the Supreme Court (judicial). The Prime Minister is designated by the Diet and in turn appoints the other members of the government. The country is divided into a number of local public entities:

- 1,722 towns and cities, *shichoson* (local level, municipalities), which are run by mayors
- 23 special wards of Tokyo, *tokubetsuku* (local level, municipalities)
- 47 prefectures *todofuken* (regional level), which are headed by governors.

The country is also divided by tradition into eight regions, but which do not constitute an official administrative division.

Figure 1 Map of Japan with prefectures and a zoomed image of the affected prefectures in eastern Honshu



Source: Graphic design by Svensk information

**Table 1 Administrative level and population (millions)
for the most affected areas**

Region	Prefecture
Tohoku (9.3)	Iwate (1.3)
	Miyagi (2.5)
	Fukushima (2.0)
Kanto (42)	Ibaraki (3.0)
	Chiba (6.2)

Japanese society has a large degree of local autonomy governed by the Local Autonomy Law (*Chiho Jichi Ho*). The Law regulates the organisational and administrative framework for the various local public entities, and indicates the fundamental relationship between local authorities and government agencies at a central level. The local public entities are considered autonomous, but since they are funded centrally, the central level has some influence in several areas [¹,²].

The Japanese Emergency Management System

The basis for the Japanese emergency management system is the Disaster Countermeasures Basic Act that describes the disaster management system and the division of responsibilities between national, prefectural and municipal levels (Figure 2). At the national level, there is a comprehensive disaster management plan (Basic Disaster Management Plan), which consists of a number of specific plans for different types of disasters. In addition to the overall plan, it is the responsibility of all designated government organisations and designated public corporations to develop their own Disaster Management Operation Plan for their particular area of responsibility. The government develops national laws and policies while it is the responsibility of the prefecture to put these laws into effect and support the municipal level to enable them to prepare and, in the context of a disaster, implement their disaster efforts.

Figure 2 The Japanese disaster management system

National level Prime minister Central Disaster Management Council Designated Government Organizations Designated Public Corporations
Prefectural level Governor Prefectural Disaster Management Council Designated Local Government Organizations Designated Local Public Corporations
Municipal level Mayors of Cities, Towns and Villages Municipal Disaster Management Council

The operational rescue responsibility lies largely at a municipal level. In a serious incident, the municipalities and prefectures activate their emergency management functions with coordination functions to lead the response efforts. When major disasters occur, an emergency response team is convened at a national level to gain an overall understanding of the situation and if necessary, coordinate emergency measures and response efforts. A national disaster management function is activated and, depending on the scale of the disaster, a Headquarters for Major Disaster Management or a Headquarters for Extreme Disaster Management is established. This is headed by the Minister of State for Disaster Management, or the Prime Minister, respectively who is tasked with coordinating the relevant authorities, emergency response initiatives and compiling strategic information.

The Swedish Emergency Management System

The Swedish emergency management system is based on the responsibility principle, the equality principle and the proximity principle.

“The responsibility principle means that the person responsible for an activity under normal circumstances should have corresponding responsibilities in emergency and war situations.

The equality principle means that the organisation and localisation of an activity must, as far as possible, be consistent in times of peace, emergency and war. The proximity principle ultimately means that emergencies can be handled at the lowest possible level in society...”. [3]

National Level

The Central Disaster Management Council

The Central Disaster Management Council is one of several councils within the Cabinet Office which handles critical policy issues. The Council includes the Prime Minister, the Minister of State for Disaster Management, Chief Cabinet Secretary, all ministers and heads of a number of major public institutions (including the Japanese Central Bank and the Japanese Red Cross) and experts. A number of technical investigative committees and a Secretary Organization are linked to the Central Disaster Management Council.

The Council promotes comprehensive disaster countermeasures, which includes developing overall emergency preparedness planning (Basic Disaster Management Plan), and promotes their implementation.

Ministries and Authorities

with Designated Disaster Management R

There are a number of designated government organisations and designated public corporations with special disaster preparedness responsibilities. They all have the responsibility to develop and promote implementation of Disaster Management Operation Plans, within their own areas of responsibility.

Fire and Disaster Management Agency

The Fire and Disaster Management Agency (FDMA) falls under the Ministry of Internal Affairs and Communications, and has great responsibility for

Japanese disaster management efforts. FDMA has overall responsibility for the firefighting services and ambulance services in Japan, and for all the planning, preparation, training and exercise for serious incidents. It is also responsible for prevention measures, planning for dangerous goods safety systems, policies for petrochemical complexes, equipment issues, research and development. The FMDA is also responsible for civil protection and for drawing up guidelines for regional planning of serious incidents regardless of cause, and maintaining warning and evacuation preparations, experts in various fields and proposing plans for firefighting communication systems.

The FDMA can mobilize support mechanisms, Emergency Fire Rescue Teams, following a serious incident when the available resources are inadequate or need to be reinforced with specially trained response staff [4].

Ministry of Health, Labour and Welfare

The Ministry of Health, Labour and Welfare (MHLW) is responsible for healthcare and nursing at a national level in Japan and for promoting disaster medical planning, preparedness and sustainability. The MHLW is also responsible for the Disaster Management Operation Plan (national disaster medical planning) and developing guidelines for how regional and local planning and preparedness should be implemented. The MHLW is also responsible for ensuring that there are trained teams (Disaster Medical Assistance Teams, DMATs) that can be mobilized in connection with a serious incident or disaster if the existing healthcare resources need to be strengthened.

Self Defence Forces

According to the constitution that Japan adopted in 1946 the country must not use the term military forces. Self Defence Forces (SDF) are used instead. They are divided into three areas which focus on defending Japan's land, air and sea territories. SDF's activities include civil protection, international peace cooperation operations and disaster relief efforts.

These forces are included in the disaster management system and, in the event of disasters and other major incidents, can assist in operations such as search and rescue for accident victims, assisting vessels and aircraft in distress, limiting the damage associated with floods, medical treatment, and transporting personnel and supplies [5].

Nuclear Regulation Authority

Since 2012, Japan has a new organisation and structure for authorities operating in the nuclear energy field with the creation of the new agency the Nuclear Regulation Authority. When the triple disaster occurred, the Nuclear and Industrial Safety Agency (NISA) and the Nuclear Safety Commission (NSC) were in place.

NISA was the Japanese agency for nuclear energy safety, while NSC was tasked with promoting Japanese nuclear safety, and administering the normative and supervisory authorities in the nuclear energy and radiation safety field. NSC proposed threshold values for decontamination in the field. These proposals were then considered by other authorities when making their own assessments and establishing threshold values [6]. For more information, see Preparedness in Japan – Nuclear Accidents.

Designated government organizations and public corporations with disaster management responsibilities

In 2011 there were 56 government organizations and public corporations with designated disaster management responsibilities. These also include independent authorities such as the Bank of Japan, the Japanese Red Cross Society, the Japanese Broadcasting Corporation (NHK) and Nippon Telegraph and Telephone Corporation (NTT) and a number of electricity and gas companies. They all have the responsibility to develop and implement Disaster Management Operation Plans, within their own areas of responsibility.

Regional and Local Levels

Prefectural and municipal disaster management organisations are responsible for Local Disaster Management Plans being developed and implemented at a regional and local level in their respective areas of responsibility and based on local circumstances.

The municipalities are responsible for the existence of functioning rescue and ambulance services, and for these liaising with each other. The larger hospitals have their own ambulances which are primarily used for transport between hospitals. However, in a disaster situation, they can also be used for emergency cases. With respect to the rescue services, the system is based on both permanent staff and volunteer teams. The municipality has “Firefighting Headquarters” with a number of rescue service stations, “Firefighting Stations”, associated with them. The number of stations is based on population levels. All municipalities except for one supplement the permanent workforce with retainer “Firefighting Teams”, which are in turn subdivided into a number of local branches (“Chapters”). There are about 159,000 permanent employees and about 879,000 voluntary rescue service staff in Japan. In the event of serious incidents where the municipality's own resources are insufficient, neighbouring municipalities may provide support. For major incidents, the affected prefecture gets support from other prefectures. In a major disaster, of the scale that hit Japan in 2011, the FDMA can mobilise Emergency Fire Fighting Teams at the request of the affected prefecture.

The prefectures and municipalities that are near nuclear power plants are responsible for the planning of nuclear preparedness. Prefectures with nuclear power plants exercise self-supervision and have some responsibility for contingency planning. Municipalities located within the 10 km zone of a nuclear power plant must also maintain a degree of preparedness.

Japanese Healthcare

The healthcare system in Japan is well developed and there are about 2.3 doctors per 1,000 population (a total of 290,000 doctors in Japan), which can be compared with Sweden's 3.8 doctors per 1,000 inhabitants (OECD Health Data 2012). More than 30 per cent of the population are over 60 years old (23 per cent over 65), which means that Japan has the oldest population in the world. On average, each woman has 1.26 children. This combined with

the fact that Japan is a high-income country means that the healthcare burden is dominated by non-communicable diseases.

Japanese healthcare is driven largely as a non-profit activity where, according to Japanese law, profit-making companies may not own hospitals, clinics or health centres. Furthermore, these are always managed by a doctor. The majority, about 80 per cent, of Japanese hospitals are owned privately by doctors. Japan differs in terms of hospitals and clinics where a hospital has at least 20 beds and a clinic has less than 20 beds. This means that the size of hospitals vary from 20 beds up to around 1,000 beds. Many hospitals are specialist hospitals for a diagnostic group or certain surgical procedures, such as organ transplantation, infectious diseases, paediatric medicine or blood diseases and cancer care. Japan has about 80 university hospitals and a large number of smaller hospitals at a regional and local level. In the Fukushima prefecture, there is one university hospital and a number of regional and local hospitals. The Miyagi prefecture has the same distribution.

All Japanese citizens are covered by a health insurance system through one or more insurance policies. This also applies to all foreign nationals residing in Japan. The health insurance system in Japan is very similar to the Swedish system, but it is the employers who pay the bulk of the insurance and they are also responsible for the dependants of its employees. Health insurance covers 70–100 per cent of the costs depending on the type of care that is requested. The state will bear the costs of the necessary care and treatment not covered by insurance.

Preparedness in Japan

Japan is at constant risk of being hit by earthquakes as the country is situated where three tectonic plates meet. Japan has a well-developed system to quickly warn of any impending earthquakes (“Earthquake Early Warning,” EEW) and tsunamis, which are issued by the Japan Meteorological Agency [7]. In addition, the country is also affected by other natural disasters such as volcanic eruptions, cyclones, severe snowstorms and floods caused by torrential rain.

The last major earthquake, “The Great Hanshin-Awaji Earthquake”, occurred in 1995 and devastated large parts of Kobe. It is estimated that about 5,300 people died and around 35,000 were injured [8]. Following the Kobe earthquake, the Japanese emergency preparedness plan for earthquakes was revised.

Buildings that have been built after 1981, when the “Amendment of Building Standard Law” came into force, have a higher level of safety in connection with earthquakes than older buildings. A new impetus has been given to earthquake-proof buildings initiated in 2005 as the Japanese authorities have discovered that a large percentage were still not earthquake-proof (20 per cent of homes, 30 per cent of schools and 40 per cent of hospitals) [7].

Emergency preparedness exercises must, according to the “Disaster Countermeasures Basic Act”, be carried out on a regular basis [7]. This takes place at a national, regional and local level with participants from both the general public and the professional ranks. In Japan there is also an awareness of the importance of teaching children what to do in an earthquake or tsunami and therefore disaster preparedness is part of the school curriculum. In 2009, the

Fukushima prefecture implemented an exercise with an earthquake scenario and subsequent tsunami. A total of 11,000 participants took part from the rescue services, healthcare, and the local population.

The general public also has good knowledge of tsunami warnings. Assembly points have been established and the general public know where to go if a warning is issued. The alarm system for tsunamis is well-developed and is tested several times a year. Additionally, evacuation procedures are practised by the general public regularly after a tsunami warning. In some vulnerable areas, protective walls have been built to provide protection against tsunami waves. They have been built in places where the risk is considered to be the greatest, based on location and seabed profile.

A major part of the disaster plans are based on earthquakes. However, several of the interviewees pointed out that many authorities have no specific plans for how to handle a tsunami disaster.

Preparedness in Japan – healthcare

Healthcare is also making active efforts to prevent vulnerabilities against earthquakes. In 2009, 60 per cent of all hospitals were built to withstand an earthquake, and the goal is that 80 per cent of all hospitals and emergency rooms will be earthquake-proof in 2014

Healthcare regularly practice managing earthquakes, with exercises of varying sizes and scope. Some exercises are carried out locally with a hospital, while others cover all or part of the prefecture. Healthcare exercises are carried out in conjunction with the rescue services, self-defence forces, the police and authorities at a local and regional level.

At a regional and local level, all of Japan has disaster medical planning for earthquakes. Preparedness at the hospitals also means that they have supplies of electricity, water, food, medicines as well as expendables to cover all needs for at least 3–7 days. When it comes to serious incidents at nuclear power plants, there are designated hospitals that have the planning and the skills to take care of injured or contaminated people. This applies to hospitals located near a nuclear power plant (10-20 miles). The Fukushima prefecture has six hospitals with expertise in the RN field. As a result of the tsunami, four of these were destroyed or are unusable [⁹].

Disaster Medicine

Following the Kobe earthquake in 1995, the system of voluntary emergency medical teams, the Disaster Medical Assistance Team, or DMAT, was founded which deploy to the affected areas within a few hours. The hospitals that have certified DMATs have contracts with the state and receive compensation for having teams on standby. However, the Ministry of Health, Labour and Welfare (MHLW) has overall responsibility for the DMAT.

Disaster medical teams are available at 200 hospitals around Japan. According to MHLW, there were just over 6,000 DMAT members spread over 480 medical units throughout Japan in December 2011. The teams are activated by the affected prefecture contacting MHLW, which is then responsible for the DMAT-hospital and individual DMAT members being contacted and activated.

The idea is that each team must consist of a doctor, a nurse and a logistician, but this has varied according to the assignments the teams have so far had [¹⁰]. DMAT staff have undergone a four-day course in emergency

medicine which is focused on handling injuries following an earthquake. After completing the training, the teams are certified by MHLW. The teams must be able to quickly integrate into hospital routines with care of the injured as an extra healthcare resource and are managed on site by the hospitals they have been deployed to. A team is expected to be available for a maximum of 72 hours. They have no medical supplies with them apart from their own food and equipment in order to be self-sufficient during this period.

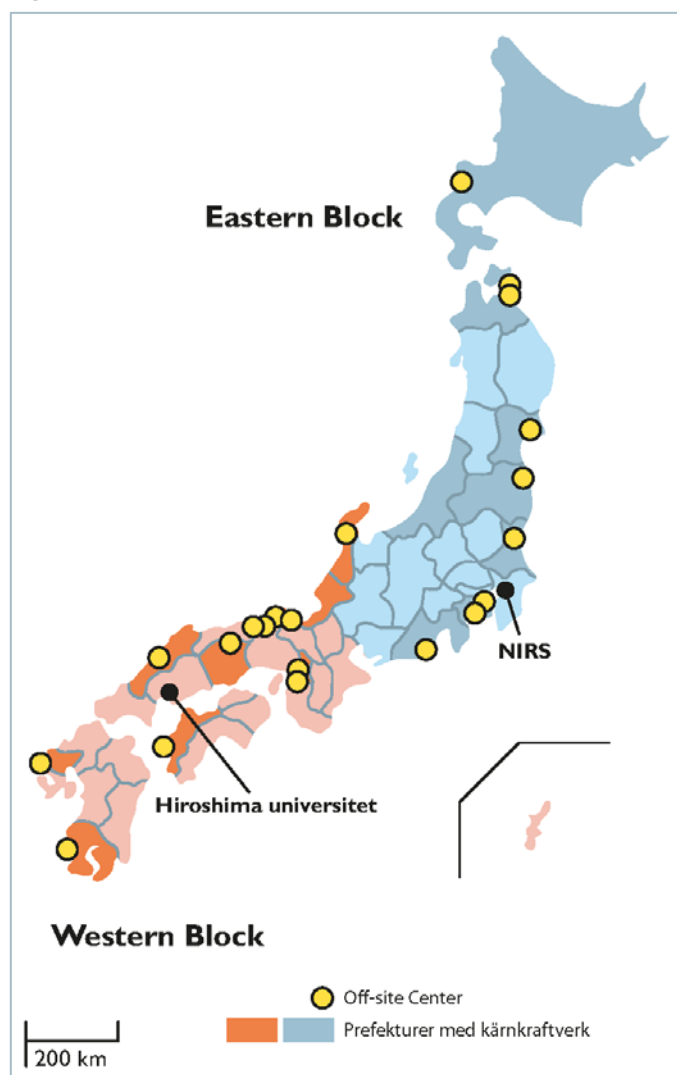
Radiation Emergency Medicine

After previous accidents involving ionizing radiation in Japan, a national plan and organisation for Radiation Emergency Medicine, REM, was created, see Figures 3 and 4. This included preparations for this kind of incident being strengthened following the accident at the nuclear power plant in Tokaimura in 1999 when three workers were seriously injured after exposure to ionizing radiation, two of whom died [11].

There are 19 prefectures (equivalent to counties) that have nuclear power plants in their areas or in nearby areas. Japan's preparedness is divided into a western and an eastern block. The highest medical level consists of two tertiary hospitals with specialist skills in radiation emergency medicine

- University Hospital in Hiroshima (western block)
- National Institute of Radiological Sciences, NIRS, a few km from Tokyo (eastern block)

Figure 3 Prefectures with nuclear power plants



Source: Graphic design by Svensk information

Their job is to act as qualified medical support for local healthcare services, and to provide advice and guidelines for the management of patients injured by radiation. The hospital in Hiroshima also possess a number of highly specialised inpatient care beds for this population, while NIRS primarily acts as an oncology hospital with advanced radiotherapy, although without intensive medical care. Previously, patients with severe REM problem have been treated at the University Hospital in Tokyo with specially trained doctors from NIRS as bedside consultants.

The tertiary hospitals are to determine the type of exposure and the severity of radiation the patients have been exposed to, sometimes with the help of advanced clinical and biological dose calculations. They should also be able to offer exposed individuals highly specialised therapy, sometimes of an intensive character and include stem cell transplantation (Figure 5). It is also the tertiary hospitals that are responsible for long-term monitoring of patients exposed to radiation that are at risk of medically critical complications.

The authorities have also appointed a number of regional or larger local hospitals to *secondary hospitals* for radiation emergency medicine. They

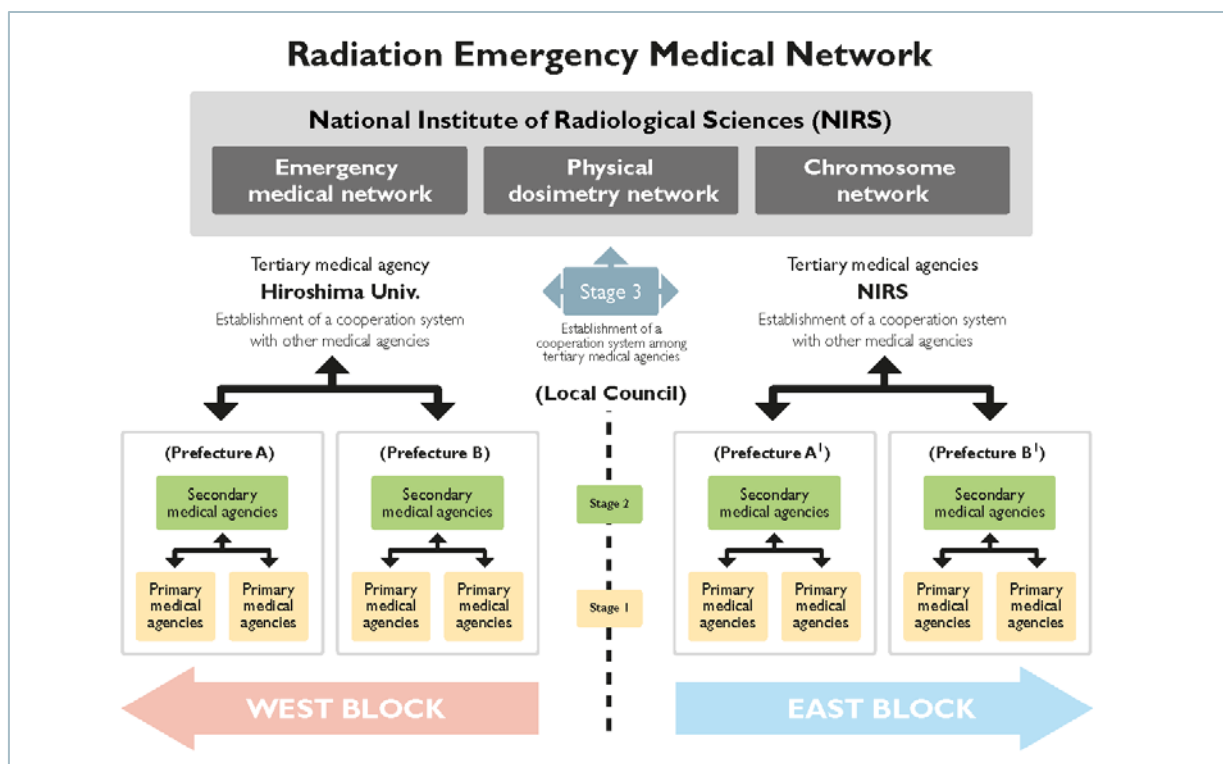
must be able to perform certain types of dose calculations (including whole body counting), and be able to deal with minor injuries caused by local radiation exposure and healthcare for patients hospitalised for observations and simpler treatments. Small hospitals located near nuclear power plants often have assignments such as *primary hospitals* for individuals who have been acutely exposed to radiation. They can perform radioactivity measurements (i.e. determine if patients are contaminated) and, if necessary simple decontamination and primary emergency care. Thereafter, patients must be able to be transported to the secondary or tertiary level. The Fukushima prefecture has five primary hospitals and one secondary (university hospital in Fukushima).

Tertiary hospitals: Highest medical level, responsible for advice and guidance. Can also receive injured patients who need highly specialised healthcare.

Secondary hospitals: Whole body counting. Take care of injuries caused by localised radiation. Inpatient care where tertiary hospital resources are not needed.

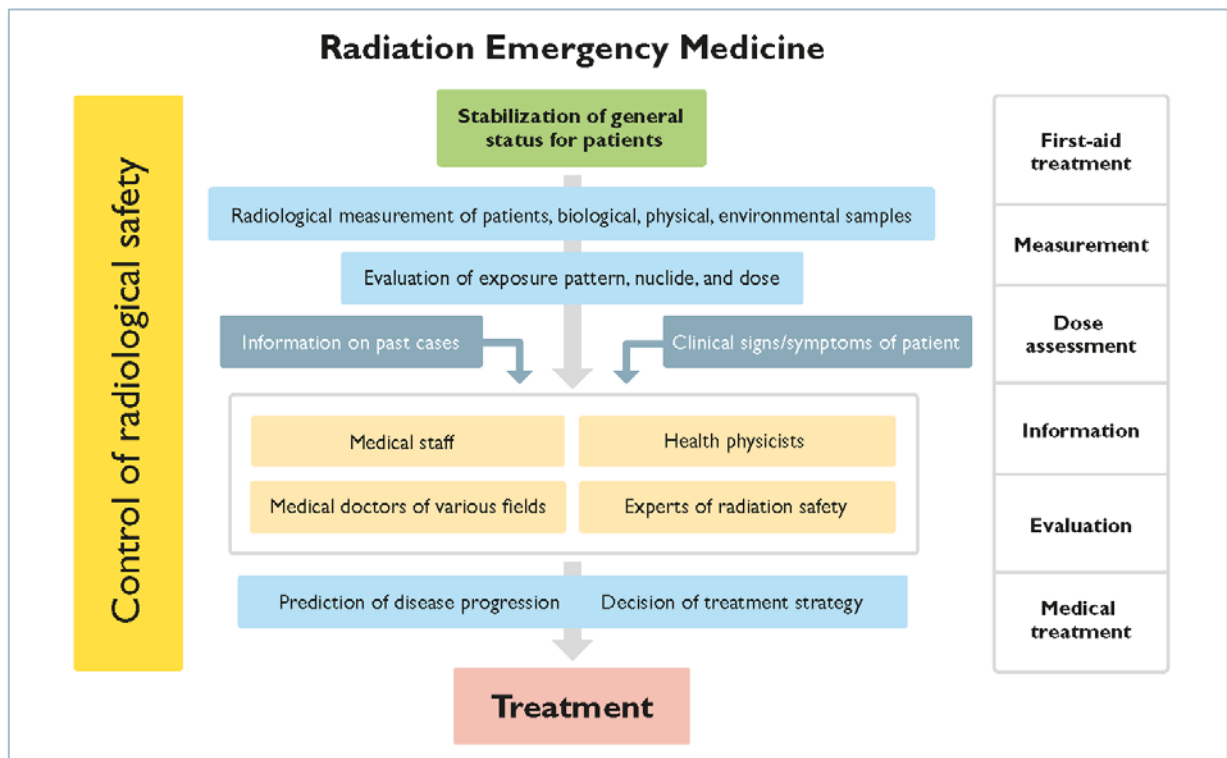
Primary hospitals: Contamination controls and basic decontamination. Stabilisation and triage to the next level.

Figure 4 Radiation Emergency Medical Network



Source: Graphic design by Svensk information according to data from NIRS

Figure 5 Radiation Emergency Medicine



Source: Graphic design by Svensk information according to data from NIRS

Japan has a telephone line that is staffed and open around the clock to which healthcare can turn for help with radiation-related issues. NIRS has the capacity to deploy Radiation Emergency Medical Assistance Teams (REMAT) around the clock, all year round. The team consists of doctors, nurses, medical physicists and radiation protectors who have access to extensive equipment of measuring instruments and specially equipped, larger ambulances (Figures 6 and 7). They can assist with determining dosage, triage, diagnosis and treatment. They also provide advice to local hospitals, and if there are signs of internal contamination, they can recommend suitable pharmaceuticals which are also carried in the REMAT ambulance.

Figure 6 REMAT ambulance



Source: Magnus Simonsson

Figure 7 Protective equipment for healthcare professionals



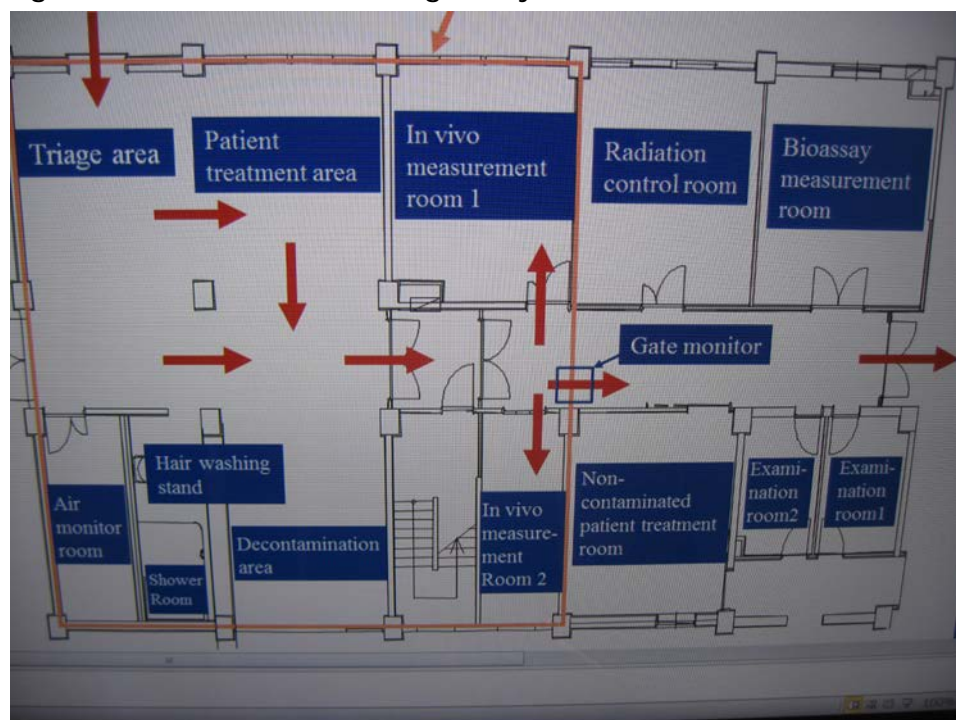
Source: Magnus Simonsson

The organisation has, among other things, the following guidelines as a basis [12]:

- Guideline on Radiation Emergency Medicine (2001)
- Guidance on Mental Healthcare in nuclear emergency (2002)
- Guidance on Roles of tertiary medical Agencies (2002)

Training activities are frequent and the NIRS has a special training facility for dealing with acute radiation injuries which can also be used in real-life situations (Figure 8). However, these have not yet been used for any patient acutely affected by radiation [13].

Figure 8 Overview of NIRS training facility



Source: Magnus Simonsson

The Japanese Red Cross

The Japanese Red Cross is a volunteer organisation with more than 15 million members who have a long tradition of acting in disasters. The Red Cross is present in all prefectures and coordinates its work with the authorities at a prefecture and municipal level. Altogether, the organisation has 90 emergency care hospitals, but not all have an emergency room that is open around the clock. The Red Cross has 31 hospitals that provide highly specialised emergency care that are open every day, around the clock [14].

Red Cross Hospital in Ishinomaki, Miyagi Prefecture

The Red Cross Hospital in Ishinomaki is newly built (2006) and has 450 beds and 120 doctors serving an uptake area of 220,000 people. The emergency medical plan was revised in 2008 when it also conducted a full-scale exercise, which meant the plan was recently updated when the disasters struck Japan in 2011. In 2010 a coordinating council was initiated with representatives from the prefecture, self-defence groups, coast guard, civil defence, the police, regional DMATs and nearby local hospitals. The hospital also had agreements with a number of different operators in order to ensure telephone communications, food and tents.

Red Cross Hospital in Fukushima

The Red Cross hospital in Fukushima has 359 beds, 47 doctors, 264 nurses and other staff, including bio-medical analysts, radiographers, pharmacists and volunteers. The hospital is located about 60 km from the nuclear power plant and prior to March 11, 2011 was not tasked with being the receiving hospital for major incidents at the nuclear power plant. As a result, the hospital had not trained or held exercises for its staff for nuclear accidents, which also meant that they lacked specific RN skills and specific measuring

equipment for its own DMATs. Before the nuclear accident, the hospital had no equipment to perform whole body counting either. However, a whole body scanner was installed on March 20, 2011 enabling the hospital to begin measurements of the population based on the guidelines that were submitted by the prefecture and NIRS.

Fukushima Medical University

Fukushima Medical University has 778 beds and is a secondary emergency hospital for emergency radiation medicine that can handle whole body counting (screening), decontamination and emergency healthcare. The hospital also has 35 DMATs.

Tohoku University School of Medicine, Miyagi Prefecture

Tohoku University is located in Sendai and collaborates with Tohoku University Hospital in several areas in terms of education and training. They have secured a major contract to monitor the population following the triple disaster.

Preparedness in Japan – Nuclear Accidents

Japanese preparedness for nuclear accidents is based on cooperation between regional and central levels. The main operators in March 2011 were

- the central emergency management in the Prime Minister's Office
- the Japanese Agency for Nuclear Safety (NISA)
- the Japanese Nuclear Safety Commission (NSC)
- regional emergency management.

The regional emergency management brings together representatives from regional and municipal levels, and works out of specially prepared premises close to the stricken plant.

The central emergency management team coordinates emergency efforts and decides on protective measures for residents living around the plant. NISA was responsible for continuously monitoring the situation and reporting to central emergency management while NSC had an advisory role in radiation protection issues. Regional emergency management is responsible for proposing and implementing the agreed safety precautions, coordinating regional efforts and liaising with the stricken plant. Responsibility for the adoption of safety precautions can also be delegated from a central to regional level.

When the accident occurred, there was an emergency planning zone covering a radius of 8-10 kilometres around the nuclear power plants and major research reactors. The exact size of the emergency planning zone was set individually for each facility. The emergency planning zone around Fukushima Dai-ichi was 10 kilometres. Within the emergency planning zone there were systems with short notice to provide information to residents, a plan for implementing safety precautions such as indoor facilities and escape routes, and a system to monitor radiation levels [¹⁵, ¹⁶].

Emergency planning zone around Swedish nuclear plants

The internal emergency planning zone is an area that stretches 12-15 kilometres out from each Swedish nuclear power plant. Within this zone, households have been given iodine tablets and information about what to do if a nuclear accident occurs. The zone also has an early warning system for the general public, both indoors and outdoors, in the event of an accident. In the internal emergency zone, the County Administrative Board plans and practices in order to quickly and accurately identify a radioactive leak after a nuclear accident. Moreover, there are procedures in place to vacate the general public within this zone.

The indication zone extends about 50 kilometres from the nuclear power plant. The indication zone has a plan for identifying a radioactive leak after an accident.

In Japan, iodine tablets are available in regional inventories, but they are not pre-distributed to the residents living around nuclear power plants. Central emergency management as well as the governor of the prefectures containing nuclear power plants can both order the distribution of iodine tablets and recommend people to take them.

The Nuclear Power Plant in Fukushima

Before the triple disaster, Japan was the third largest producer of nuclear electricity and about 30 per cent of its electricity came from nuclear power. Overall, there were 54 reactors divided over 17 nuclear power plants. Along the north-east coast, four nuclear power plants were affected by both the earthquake and the tsunami: Onagawa, Fukushima Dai-ichi, Fukushima Dai-ni and Tokai.

The Fukushima Dai-ichi, or Fukushima 1 nuclear power plant is located on the coast facing the Pacific Ocean in the prefecture of Fukushima in north-eastern Japan, about 230 km from Tokyo. Before the accident, there were six reactors and an intermediate repository for spent nuclear fuel. The first reactor was commissioned in 1971 and the last one in 1979. Reactors 1-4 are located adjacent to each other on the south side of the plant, while reactors 5 and 6 are located individually in the northern section. Reactors 5 and 6 are located at a slightly higher altitude compared to reactors 1-4.

Before the incident occurred, reactors 1, 2 and 3 were in normal operation, while reactors 4, 5 and 6 were shut down for overhaul. Furthermore, all the fuel had been transferred from the reactor vessel in reactor 4 to the spent fuel pool located next to the reactor vessel on the corresponding floor five in the reactor building. All six reactors at the Fukushima Dai-ichi plant are boiling water reactors with the same basic design, although from different generations. This means that the oldest reactor, reactor 1, had a different emergency cooling system than reactors 2 and 3.

Sequence of Events

The Earthquake and Tsunami

On March 11, 2011 at 14:46 the north-eastern part of Japan was hit by an earthquake with a magnitude of 9.0. It lasted about three minutes, but in parts of Tohoku it lasted for up to six minutes [17]. The epicentre of the earthquake was in the sea at a depth of about 24 kilometres, some 130 kilometres east of the coast. The earthquake was the most powerful ever to hit Japan, and the fifth most powerful in the world since 1900. The tectonic plate boundaries were of the collision zone type, which meant the risk of a tsunami was great. The immediate damage from the earthquake was primarily material. However, the earthquake triggered a powerful tsunami that began hitting the east coast 26 minutes after the earthquake. Despite high protection barriers in several places along the coast, the tsunami gushed in, and in the Sendai prefecture the water reached 10 km inland in some places. It was primarily the tsunami that caused damage to property.

Figure 9 Earthquake and tsunami hit area



Source: Lee Jae-Won/Scanpix

Immediately before the earthquake hit Tokyo, the early warning system for earthquakes was activated, which collects data from over 1,000 seismographs throughout Japan. Japan's meteorological agency (JMA) immediately sent out messages to millions of telephones warning that there was a risk of a major earthquake. The warning message reached the general public thirty seconds after the earthquake occurred. Three minutes after the earthquake, JMA sent out a tsunami warning that heavily underestimated the height of the tsunami wave. Within minutes, the error calculation was corrected but this was not picked up by the news media.

A government study showed that in the three most affected prefectures, only 60 per cent of the population understood the tsunami warning, and of these 5 per cent were hit by the tsunami, while half of the 40 per cent who did not hear the warning were directly impacted by it. At first it was believed, however, that the tsunami would not be so intense in many of the areas that suffered greatly, but the expected wave height was upgraded gradually.

Around 100 of the local assembly points were flooded by the tsunami.

The Nuclear Accident

The following section is based on several reports and assessments following the nuclear accident [15,18-21].

Along the north-east coast of Japan, eleven reactors were scrambled, including the three that were in operation at Fukushima Dai-ichi. As a consequence of the earthquake, Fukushima Dai-ichi lost all contact with the external network. In line with the plan, the backup diesel plants started in all six reactors at Fukushima Dai-ichi. The reactor pressure, the water level in the reactor tank and the pressure in the enclosure were stated as being normal afterwards. However, it has not yet been determined if the earthquake damaged the plant which later influenced the sequence of events in the accident.

The earthquake caused several tsunami waves. The first big wave hit Fukushima Dai-ichi approximately 40 minutes after the earthquake. The highest tsunami wave that hit the plant was 14–15 metres high, which is more than the maximum wave height of 5.7 metres that Fukushima Dai-ichi was designed to resist. Reactors 1–4 are around 10 metres above sea level, which led to the area around the reactors being flooded with 4–5 metres of water.

The tsunami knocked out the backup diesel plants, substations and the intake for sea water. Only one backup diesel plant at reactor 6 survived while the other reactors experienced a total loss of power. Staff at reactor 6 managed to connect power from the operational backup diesel plant at reactor 6 to reactor 5 ensuring cooling could be maintained in both reactors.

Figure 10 Nuclear power accident at Fukushima Dai-ichi



Source: Handout/Scanpix

Following a total loss of power, the emergency core cooling systems can no longer be controlled, and without cooling the water in the reactor tank will boil away. When the core is uncovered, the fuel will eventually start to melt. This will produce large amounts of hydrogen, which increases the risk of explosions.

Table 2 below shows the sequence of events from the initial earthquake to the situation on March 15.

Table 2 Initial sequence of events at Fukushima Dai-ichi.

Date	Time	Incident
11/3	14:46	Earthquake and loss of external networks. Backup diesel plant starts.
11/3	~15:40	Total loss of power after the tsunami.
11/3	~17:00	The core starts to be exposed in reactor 1.
12/3	~15:30	Hydrogen explosion in reactor 1. Major damage to the reactor building.
13/3	~08:00	The core starts to be exposed in reactor 3.
14/3	~11:00	Hydrogen explosion in reactor 3. Major damage to the reactor building.
14/3	~18:00	The core starts to be exposed in reactor 2.
15/3	~06:00	Explosion sound from reactor 2.
15/3	~06:00	Hydrogen explosion in reactor 4. Major damage to the reactor building.

On March 15, three meltdowns and three hydrogen explosions occurred. Moreover, the status of the spent fuel pool in reactor 4 was extremely uncertain. The hydrogen explosion in reactor 4, which was probably caused by the leakage of hydrogen from reactor 3, caused major damage to the

reactor building and there was a concern that the fuel tank would give way. The situation at that time was critical and was characterised by great uncertainty.

The cooling could subsequently be resumed by flowing water through the reactors. However, this generated huge amounts of water contaminated with radioactive material that had to be disposed of. Heavily contaminated water also accumulated in the basements under the reactors and turbine buildings, and on two occasions, in April and in May 2011, water contaminated with radioactive substances ran into the sea via cable trenches. Additionally in April, there was a deliberate release of less contaminated water directly into the sea. The aim was to free up storage space for more contaminated water that had accumulated at the plant. The deliberate release was the smallest of the three releases, but it still attracted the most attention as it took place without prior warning and support from neighbouring countries.

Radioactive materials released into the ocean are quickly diluted and the levels in the sea water are low. However, radioactive material can accumulate in sediments along the coast, and levels that can cause problems in the future have been measured in plankton along the coast outside the prefecture of Fukushima.

Releases into air are reported in Table 3. There is also a comparison with the estimated releases from Chernobyl [18]. It is uncertain how the releases have varied over time and how much radioactive substances have been released in total, and this uncertainty is likely to persist for several years to come. However, research indicates that high releases occurred from the night of March 14 to the evening of March 15.

Table 3 Releases into the air.

	Fukushima ¹	Chernobyl
I-131 (1)	1–2*10 ¹⁷ Bq	1.8*10 ¹⁸ Bq
Cs-137	1–2*10 ¹⁶ Bq	8.5*10 ¹⁶ Bq
Cs-137 converted to I-131 (2)	4.8*10 ¹⁷ Bq	3.4*10 ¹⁸ Bq
Total (1)+(2)	5.10*10 ¹⁷ Bq	5.2*10 ¹⁸ Bq
Per cent of Chernobyl	9.5 to 19 %	100 %

¹ The Japanese Government's second report to the IAEA

The first row of the table shows the total releases of Iodine-131 and the second row shows the total releases of caesium-137. The third row shows the caesium-137 converted as if it were iodine-131, i.e. the amount of iodine-131 necessary to obtain the same radiological consistency as the specified amount of caesium-137. The fourth line shows the sum of the releases converted to iodine-131. The last row shows a comparison to Chernobyl for this sum.

Radioactive substances are carried by air masses from the release point which means it is the direction and force of the wind that controls the path of each release. Precipitation also has a great effect on ground disposition, i.e. coating of radioactive substances on the ground. This can be up to 50 times higher following fallout when rain is falling, as compared to fallout in dry weather conditions.

The air masses with radioactive substances from the release at Fukushima Dai-ichi were mostly in the valleys. The mountain chains in central Japan prevented any further spread of the radioactive cloud to some extent, at least in certain directions. For example, Japan's west coast did not suffer any fallout at all. Around 80 per cent of the releases were carried out over the

Pacific. The ground deposition that affected parts of Japan came in several rounds over the periods when winds carried releases over land. The rounds that gave rise to the highest ground depositions are listed below.

1. Releases were carried to the south-west of the plant by light winds from midnight March 14 until early morning on March 15, and to the north-west of the plant during the afternoon of March 15. Rain was observed in Fukushima from March 15 to 17. Releases over this period caused areas north-west of the nuclear power plant Fukushima Dai-ichi to have the highest ground deposition in the Fukushima prefecture.
2. Releases were carried south from midnight on March 21 to early morning on March 22. It rained in the Kanto region over this period. Releases over this period gave rise to most of the ground deposition in Ibaraki and Chiba.

Ground deposition was initially established through a combination of aerial surveys and measurements directly on the ground. Typically, the results are given either as the dose rate one metre in the ambient dose equivalent unit above ground, or as the concentration of caesium in the soil in the activity unit per unit area.

A dose rate of 3.8 microSv/h is the threshold value that the Japanese authorities have used to establish zones where the annual dose may exceed 20 mSv. For an unprotected person, the annual dose is just below 30 mSv. With protection factor 0.6, the annual dose falls just below 20 mSv. The protection factor takes into account protection against exposure to radiation that occurs when staying indoors. Staying outdoors principally reduces the radiation from the ground disposition and direct radiation from the radioactive cloud. The dose rate of 3.8 microSv/h one metre above the ground surface initially corresponds to about 560 kBq/m² (kilo-becquerels per square metre) each for Cs-134 and Cs-137, i.e. total of about 1,100 kBq/m² for caesium. This compares to a maximum of about 150 kBq/m² for caesium in Sweden after Chernobyl.

A soil sampling survey was conducted during June and July 2011 at around 2,200 sites within a radius of 100 kilometres from Fukushima Dai-ichi. The dose rate was measured one metre above the ground at each site, and five soil samples were taken for analysis. The analyses were conducted for alpha, beta, and gamma emitting nuclides. The alpha and beta emitting nuclides were analysed from about 100 sites, and there are published maps for Cs-134, Cs-137, I-131, Sr-89/Sr-90, Pu-238, Pu-239+240, Te-129m and Ag-110m. The results of this soil sampling survey are one of the main sources for the calculation of radiation doses that have so far been published.

Dose terms

Dose terms are needed to quantify the radiation that people are exposed to.

The basic dose term for dosage for a tissue or organ is **absorbed dose**.

Absorbed dose is the energy that ionising radiation transfers to a particular tissue or organ divided by the weight of the tissue or organ. The unit of absorbed dose is gray (Gy), which corresponds to one joule per kilogram.

Different types of radiation produce different effects in tissues and organs.

To compensate for this we use the dose term **equivalent dose**. The equivalent dose is the absorbed dose for an organ or tissue, weighted by factors that take into account the current biological effect of the radiation. The unit of equivalent dose is sievert (Sv).

Different tissues and organs are sensitive to radiation. In order to compensate for this we use the dose term **effective dose**. Effective dose is the sum of equivalent doses to tissues or organs, weighted for their sensitivity for radiation. The unit of equivalent dose is sievert (Sv).

The effective dose is therefore a way of expressing the dose to a person from all types of exposures, from all types of radiation and no matter how the exposure happened.

The equivalent dose to the thyroid is important in connection with the release of radioactive iodine in nuclear accidents. The reason is that this dose can be minimised by taking iodine tablets.

Damage and Disturbances

Community and Infrastructure

The damage to infrastructure along the coast was devastating. Around 400,000 people were made homeless as a result of the tsunami, and it caused a shortage of food, water, medicine and fuel. About 130,000 houses were totally destroyed in the six prefectures (Table 1) along the north-east coast hit by the tsunami, while 250,000 were “semi-destroyed” and almost 700,000 partially damaged.

Fire department reports show that 360 fires were extinguished over the first days in the affected area. Around a quarter of a million cars and lorries were damaged or destroyed. Roads were washed away and the ground was covered with mud mixed with debris from houses and factories and other rubbish. The roads that remained were largely impassable due to the destruction and debris. There was also a major shortage of fuel. This made it difficult for rescuers to reach the injured and victims, and transporting the injured and sick was a huge problem over the first few days.

In addition to falling buildings, supplies of electricity, water and heat were completely knocked out and many industrial companies were damaged. The earthquake and tsunami also knocked out a large number of thermal power plants, in addition to the eleven reactors which were scrambled at four nuclear power plants or, in one case, destroyed [22].

According to the Ministry of Economy, Trade and Industry more than 4 million homes were hit by power failures. In some places, it took up to six weeks before restoring electricity supplies and then it was rationed due to the accident at Fukushima and because the other nuclear power plants were scrambled and many thermal power plants were out of service. Around 1.5 million households were without water, which took weeks to restore. Telecommunications were down for several days, although the Internet worked thanks to buried cables. The Internet was the primary communication channel over the first few days. Three weeks after the tsunami, 200,000 people still lacked electricity while 650,000 households still had no access to running water.

A total of 15 hospitals in eight of the affected coastal communities were severely damaged. The Iwate prefecture was one of the worst affected, with three hospitals completely destroyed while half of all clinics and health centres were damaged. Around 40 of about 120 clinics in the coastal area were washed away by the tsunami.

The World Bank estimates that the tsunami caused damage of around USD 235 billion, which makes it the most expensive natural disaster in the world ever [23].

Deaths, Injuries and Disease

The Japanese police reported in September 2012 that a total of 15,870 people died from the tsunami and that 2,814 were still missing. Among those killed,

65 per cent were over 60 years, including 25 per cent over 70 years. The cause of death is reported to be drowning in 92 per cent of the cases, while 4.4 per cent were crushed under collapsed buildings. 1.1 per cent are estimated to have died from burns and the rest due to hypothermia and other non-specific causes. The official number of injured is 6,114 people [24] But the number varies between 5,200 and 8,000 depending on the source. This is partly due to the difficulty defining what is meant by injured. It could include people with minor wounds not requiring medical care but also severely injured who need advanced trauma surgical treatment.

The number of serious injuries was relatively low and was not the dominant health problem, apart from the first days when many people with minor injuries sought treatment. There are no reports that the number of serious injuries caused healthcare resources to be overworked.

Non-specific respiratory problems are said to have been one of the main health problems, but there are no figures to confirm the number of victims. There has been speculation about the genesis of respiratory symptoms. It is likely that many people had inhaled seawater. But for the most part problems were stated to be caused by the dust in the air over the first days. The number of people with respiratory problems decreased gradually.

No epidemics were reported, but from time to time, the number of diarrhoea cases rose at one assembly centre where the water and hygiene situation was poor.

A major proportion of the disease burden in the first day after the tsunami related to chronic diseases such as hypertension, cardiovascular disease and diabetes. The primary reason was that the patients had lost their medications but were also exposed to increased stress. One problem was that patient records were missing which hampered the prescribing of medication.

Among the approximately 400,000 people made homeless, many had non-communicable diseases. The care establishments that treated them had been destroyed along with many pharmacies. During the first few weeks, there was therefore a lack of drugs to treat illnesses such as diabetes, hypertension and cardiovascular diseases. Temporary shelters were created in schools, gymnasiums and other large spaces for these people. In connection with the emergency evacuation to temporary housing, some of these patients, mainly the elderly with clear health needs, were also in need of nutrients and were cold in addition to a lack of medication.

Another medical problem, mentioned by Japanese staff to the Kamedo group orally, was that several ambulances carrying people with suspected radiation contamination were denied access to medical care units (emergency rooms, and the like) for the fear of radiation among the receiving healthcare staff. In some cases this led to markedly longer journeys and delayed medical care. In several cases medical staff also simply abandoned medical facilities with patients, often the elderly, just because of the fear of being seriously exposed to radiation through contaminated patients. Refusal to accept suspected contaminated patients, or to remain with non-evacuated patients, in these cases, could not be justified from a medical or nuclear radiation aspect and meant obvious medical risks to patients. This phobia is almost entirely explained by a lack of knowledge.

Psychological and psychiatric disorders were also reported to have increased, but there is no clear classification and definition of these disorders, making them impossible to quantify.

Complications in Connection with Evacuations from Municipal Residents and Hospitals, a Medical Perspective

There were eight hospitals and 17 nursing homes within 20 miles of the Dai-ichi nuclear power plant. When the earthquake hit, there were 1,240 patients that had been admitted to hospitals and 980 to nursing homes. Many were evacuated in relatively calm circumstances over the first few days, and 840 patients remained when, on the evening of March 13, an emergency evacuation was ordered due to the deteriorating situation at the nuclear power plant. At dawn on March 14, these patients were evacuated to Minamisoma for screening (26 kilometres from the nuclear power plant). No medical staff went along. Bedridden patients lay on seats wrapped in blankets and sheets, and some were injured when they rolled down onto the floor. The evacuation continued during the day, but when the situation deteriorated further, police vehicles were also put into use.

There was not enough room for everybody at the receiving units which meant that some were left at a temporary assembly hall (a meeting room) without heating and medical equipment. It took up to 24 hours before they were admitted to another facility. 27 patients with severe medical conditions, such as renal failure, and strokes, were transported more than 100 km to Iwaki. On March 15 there were 12 deaths, of which 10 had died during transport. A total of 50 patients died during the evacuation or shortly thereafter. The causes were judged to be hypothermia, dehydration and/or due to a worsening of their underlying medical conditions. No significant contamination was observed in any of the evacuees.

Several of the deaths could probably have been avoided if there had been a well-rehearsed plan in place for evacuation [²⁵].

Medical Injuries and Health Effects Related to the Nuclear Accident

In connection with the nuclear accident at Fukushima Dai-ichi, there were major releases of radioactive substances from the reactors, with a risk of adverse health effects. Those workers who served at the plant during and immediately after the serious sequence of events were the most vulnerable, and many of them were exposed to doses of ionising radiation that well exceed the applicable limits (167 people received doses above 100 mSv). Below is a more detailed description of this exposure, and of the measures taken, under the heading “Radiation protection measures at the plant”.

In conclusion, there was no evidence to suggest that anyone subjected to high radiation doses had suffered from *acute radiation syndrome* (ARS) as a direct result of the radiation. In total there were about 150,000 inhabitants who were evacuated from the vicinity of the plant on the government's directives due to radiation risks, and of these 60 passed away in March 2011. These deaths are deemed to be a direct consequence of the evacuation and the problems, mainly logistical, that this entailed (see also above).

Routes of exposure following a release from a nuclear power plant

Upon the release of radioactive material from a nuclear power plant, people can be exposed to radiation in several different ways. The main ways are that they:

- are exposed to direct radiation from radioactive substances in the air
- inhaling radioactive substances in the air
- are exposed to radiation from radioactive substances on the ground
- ingest radioactive substances from food or drink.

It is difficult to assess the long term effects of the relatively low level of ionising radiation due to the nuclear accident, in addition to the normally occurring background radiation. However, significant amounts of radioactive material remains, mainly in the vicinity of the nuclear power plant, although decontamination work is still in progress (see the environment and decontamination section below). There are various models for estimating the long-term risk of cancer, particularly due to radiation [26]. The risk depends on several factors, mainly the radiation dose but also the person's age following exposure and the type of exposure etc.

WHO's Follow-up After the Nuclear Accident

In May 2012, WHO published a report with estimated doses to adults, ten-year olds and one-year infant children as a result of the nuclear accident in Fukushima. The report presents doses from the Fukushima prefecture, prefectures bordering Fukushima, other prefectures in Japan, neighbouring countries to Japan and the rest of the world.

The information pertains to effective dose and equivalent dose to the thyroid gland from exposure over the first year following the accident. The estimated dose takes into account the radiation dose from the passing radioactive cloud during the release, the radiation dose from inhalation of radioactive material in the radioactive cloud during the release, the radiation dose from radionuclides on the ground and the radiation dose from ingestion of contaminated food, including drinking water.

The report is based on the information that was available until the middle of September 2011. The dose estimates in Japan are based on the measurement data, primarily from fallout measurements and measurements of food while dose estimates outside Japan are based on an assumed source term and dispersion calculations, as the measurement data is largely missing.

The following values are defined as the estimated effective dose:

- In the Fukushima Prefecture, the estimated effective dose lies within the range of 1–10 mSv, except in the two municipalities of Namie Town and Iitate Village where the estimated effective dose is in the range of 10–50 mSv.

- In prefectures close to Fukushima, the estimated effective dose ranges from 0.1–10 mSv, and in other prefectures in Japan, the estimated effective dose is in the range of 0.1–1 mSv.
- Outside Japan, the estimated effective dose is below 0.01 mSv.

In the most affected areas, the estimated effective dose comes mainly from the ground deposition, while food is the principal source at greater distances.

The following values are given as estimated equivalent dose to the thyroid gland:

- In the most exposed parts of Fukushima prefecture, the estimated thyroid dose falls in the range of 10–100 mSv, with the exception of one municipality in which the dose for adults is in the range 1–10 mSv and another municipality where the estimated thyroid dose for infants is in the range 100–200 mSv.
- In the rest of the prefecture, the estimated thyroid dose is in the range of 1–10 mSv for adults and 10–100 mSv for children and infants.
- In the rest of Japan, including prefectures close to Fukushima, the estimated thyroid dose is in the range of 1–10 mSv.
- Outside Japan, the estimated thyroid dose is below 0.01 mSv.

In the most affected areas, most of the estimated thyroid dose comes from inhalation during the passage of the cloud and the external dose from ground deposition, while food is the main source at greater distances.

The Psychological Effect

Anxiety has been a major factor in Japan since the Fukushima accident occurred. Previously, the awareness of the general public and the media focused on the effects ionising radiation can cause, despite society's experiences from the blasts at Nagasaki and Hiroshima. Radiation effects have also been exaggerated in many places and rumours spread on social media sites have had a significant impact, partly because the authorities seem to have been slow to react and not taken the initiative to inform the general public. Self-proclaimed experts started blogs, Twitter accounts and websites [15,²⁷].

These are some examples of newspaper headlines after the accident:

- Radiation on its way to YOU.
- Internal radiation causes brain damage – Chernobyl experiences
- 20 years later: deformities, strange diseases and mental retardation in Fukushima.

Members of the general public and the media began to equate radiation with cancer/death. The authorities still have a lot of work ahead of them in terms of providing information and getting the general public to understand that the doses that the majority of people have suffered mean an extremely low risk (see the Dose-effect relationship fact box).

Dose-effect relationships

When people are exposed to ionising radiation, there is a correlation between the dose they receive or have been exposed to and the consequences to their health.

The risk of *acute radiation syndrome* is governed by a threshold value. Under this threshold value you will not suffer any injury, while above the value you will be affected. There are no reported acute radiation injuries following the Fukushima accident.

The risk of *late radiation injuries* (different types of cancer) increases with an increasing dose. WHO has begun to calculate what that risk means for the victims in Japan. This is partly related to gender, age, length of exposure, etc.

Up until July 2012, NIRS had received 17,645 telephone calls from the general public, although the number had dropped considerably over the past few months. NIRS has also held 508 public seminars and prepared a tutorial that explains the relationship between radiation and health effects (Appendix 2).

Pregnant women in particular were very concerned about their unborn children even though the doses were well below the levels of concern. Likewise, many people were worried about becoming sterile in the future.

Those who worked at the nuclear power plant were treated by company doctors and nurses, but it took three weeks before there was a psychiatrist on site along with the company doctor. The workers had a variety of post-traumatic symptoms, but for reasons of resources, only those most affected could be taken care of. The Ministry of Health, Labour and Welfare also set up a psychosocial telephone support line via a freephone number. Now there is a full-time psychiatrist at the plant [28].

A month after the disaster, a psychological evaluation was conducted of 424 medical aid workers. The results showed that 9.2 per cent were concerned about radiation exposure. These individuals also had signs of more post-traumatic stress symptoms and depressive symptoms than others. The study lacked a control group, but there are similar reports from the Chernobyl accident [29]. An article in *Nature* discusses the psychological impact by featuring interviews with victims and researchers. In addition, several studies are being conducted on the population and the results will gradually be reported [30].

Environment and Decontamination

The management of radioactive waste has been a major challenge for Japan. This applies to both the waste generated by various types of decontamination efforts, and other waste contaminated with caesium such as ash from incinerators and sludge from water treatment plants. Waste containing more than 8,000 Bq/kg cannot be disposed of by following normal procedures. Instead, it is the responsibility of the state to dispose of this waste.

Another waste problem applies to any debris that was produced following the earthquake and tsunami. Several non-affected prefectures have hesitated to accept such waste and burn it out of the concern that the ash might be contaminated with caesium.

Food

The releases from the Fukushima Dai-ichi caused major problems to food production in Japan. The first weeks after the accident were dominated by problems with iodine in drinking water, dairy products and leaf vegetables. After some months, the iodine disappeared, but then the problem of caesium in, for example, tea leaves, meat from beef cattle that had eaten contaminated feed and rice grown in contaminated soil dominated instead.

Japan imposed food restrictions soon after the accident, from March 17, 2011. For a short time, these also included restrictions for drinking water in some regions. The initial Japanese threshold values for both iodine and caesium in food were based on the premise that no one should eat more than 5 mSv per year from food. The threshold values contained a substantial margin of safety and, for certain foods, they were lower than the corresponding Swedish threshold values for caesium, although the goal of the Swedish values is that no one should receive more than 1 mSv per year from food. Japan also quickly built up an extensive food control system with a national website where local authorities could publish all measurement results from control measurements of food. During the period March 18, 2011 to March 31, 2012, a total of around 135,600 food analyses were conducted in Japan. Of these, about 1,200 were above the initial threshold values.

On April 12, 2012 the Ministry of Health lowered the threshold values for food between 4 and 20 times with the goal that no one should eat more than 1 mSv per year.

Responses

The earthquake, tsunami, and their consequent effects led to injuries that required extensive human resources. MHLW deployed 1,800 DMAT staff over the initial 12 days, and FDMA deployed 28,600 rescue service staff (equivalent to one-sixth of all rescue service staff in Japan) to the affected prefectures of Iwate, Miyagi and Fukushima in the first three months. Around 107,000 people from SDF worked on rescue operations, transport of relief supplies and care of people who had suffered no more than minor injuries, etc. Almost 840,000 police officers worked on “search and rescue” and on identifying the deceased, and on maintaining security, etc.

The US military that were on site in Japan could therefore rapidly begin their relief efforts: Operation Tomodachi (Operation Friend). Japan also received help from numerous other countries and aid organisations. In addition the Japanese authorities calculate that approximately 960,000 volunteers have been working in the affected areas.

Alarms and Management

The earthquake and tsunami warning that was sent out meant that the rescue services were quickly alerted and mobilised. According to the plans, a national command centre was quickly established in Tokyo, and operational management was set up in the three most affected prefectures. Hospitals and ambulances were alerted but had difficulty reaching the affected area due to destroyed infrastructure and lack of information on number and location of the injured.

It was also difficult to maintain operational communications between the regional and local collaboration centres and rescue teams on site as the communications were down. Satellite telephones were used but there are reports that they did not work as expected.

The Cabinet Office's emergency management centre consisted of ten persons seconded to coordinate relief efforts at a national and international level. They were quickly overwhelmed. One strategy for managing the efforts was to create a collaboration platform to include NGO expertise which was put into use and integrated into the relief efforts.

Alarms and Management in Connection with the Nuclear Accident

The sections below are based on reports following the nuclear accident and on Japanese legislation on the nuclear emergency preparedness [15,19,31,32].

The Fukushima Dai-ichi nuclear power plant alerted the central authorities at 15:42 on March 11 after a total loss of power at the plant as a result of the tsunami. Just over an hour later, at 17:00, the central authorities were alerted once again as the situation had deteriorated. As a result, the Prime Minister announced at 19:03 that there was a nuclear emergency at Fukushima Dai-ichi, which in turn led to the Japanese contingency plan for nuclear accidents

being fully activated. In order to activate preparedness, an official declaration of an emergency is required.

However, problems soon arose as the central emergency management were already struggling to cope with the consequences of the earthquake and tsunami. Meanwhile, NISA had problems both gathering and disseminating information, the NSC had difficulty living up to its advisory role, and regional emergency management had great difficulty in managing the triple disaster at Fukushima. By way of example, the regional emergency command centre that was used for the nuclear accident was abandoned after only a few days, as it was only five kilometres from Fukushima Dai-ichi in the area that had already been evacuated on March 12.

As a result this led to the Prime Minister, together with a small group of advisers, going in and actively managing the emergency efforts. The Prime Minister visited the plant on March 15 and was on-site to assess the situation. The Prime Minister's Office also went in and exerted its influence on operations at the plant, such as for ventilation and cooling with seawater. As the regional emergency management was unable to propose any safety precautions, the central level under NISA had to take over. However, because NISA was slow to react, the Prime Minister's Office intervened and both proposed and adopted decisions on safety precautions.

Safety measures

There are various safety precautions when people risk being exposed to radiation during an accident involving radioactive substances. In order to protect the population, the authorities can order people to:

- evacuate to completely avoid or reduce exposure
- stay indoors to reduce exposure to radioactive substances in the air and on the ground
- take iodine tablets to protect against radioactive iodine
- relocate to reduce exposure that would otherwise give a dose above a stated threshold value for an extended period
- observe access restrictions to reduce exposure in areas with higher ground depositions
- observe restrictions in the agricultural and food sector to reduce exposure from radioactive substances to food.

At a regional level, there was no plan to deal with a nuclear accident caused by a natural disaster. The breakdown in communication also meant that the regional and central level were not aware of each other's actions. Lack of communication made it difficult to convey the decisions concerning safety measures to the municipalities concerned and to the general public.

Initial Measures and Pre-hospital Care

Local and national rescue efforts began within a few minutes of the powerful earthquake and tsunami. On the very day it happened, 8,400 people from Japan's SDF were deployed to the area.

Due to the lack of communication and impassable roads, it was impossible for ambulances to reach the affected area. However, helicopters could be quickly requisitioned, and they began to fly shuttles carrying the injured and others who needed care and evacuated the people who had been stranded after the earthquake and tsunami.

According to the Ministry of Health, Labour and Welfare, disaster medical teams from all over Japan were mobilised in just a few hours. A total of 380 DMATs comprising 1,800 people were deployed to the affected areas over a twelve day period, and were coordinated from the hospital level.

The problem for the teams was to reach the affected population. As the number of trauma cases was limited the hospitals were not overloaded and did not need DMAT support. Instead the teams came to work in a pre-hospital setting, providing primary care, at assembly centres and in the camps that were established in schools and gymnasiums where the homeless and victims were taken. DMAT teams set up temporary clinics and treated ailments locally but could also, when needed, evacuate patients by helicopter. However, the bulk of the work was to ensure that there were medications for non-communicable diseases and monitor sanitation and limit the spread of communicable diseases in camps with poor standard and limited space. However, the DMAT were not specifically trained for this type of public health work

Over the first ten days, 370 DMATs worked in the affected area, including 138 in Iwate, 131 teams in Miyagi, 73 in Fukushima and 28 teams in Ibaragi. In addition to DMATs, healthcare staff arrived at the affected area from the Red Cross and other voluntary organisations.

Personal Scanning and Decontamination

Radiation-related injuries were very few and mild. REMATs (Radiation Emergency Medical Assistance Teams) were of assistance and arrived 17 hours after the tsunami. Tokyo Electric Power Company (Tepco) also had its own medically trained staff at the nuclear power plant.

The emergency services are responsible for the pre-hospital emergency medical services and there are also manned medical helicopters based at some of the larger hospitals.

The Japanese Medical Association for Emergency Medicine (JAAM) deployed doctors to the local medical centre to assist with triage, first aid and decontamination. They found eight patients with external contamination.

A minor emergency clinic was set up in J-village, 20 kilometres from the nuclear power plant, to take care of the rescue workers. J-village is Japan's football association medical training facility that was converted into headquarters and accommodation for the rescue workers at the nuclear power plants. The goal was to take care of traumatic injuries and heat stroke in J-village. There was equipment to decontaminate staff and vehicles as well as dormitories, warehouses, etc. J-village was manned by emergency doctors from JAAM and other organisations. For reasons of radiological protection,

there were no ambulances from the rescue services or self-defence forces at the nuclear power plant, and no helicopters either.

After the first hydrogen explosion at the nuclear power plant, the first patient was cared for by the local emergency services. Five people were injured in the first hydrogen explosion and eleven in the second. A few contaminated patients were transported by ambulance following the explosion. After this incident, Tepco's staff transported the injured to J-village.

People with injuries were treated on site or were sent by ambulance or helicopter to prepared secondary hospitals with adequate radiation protection. Decontamination took place in J-village, and the regular ambulance staff then took over and transported the patients to hospital. This was coordinated by emergency doctors, and both ambulances and helicopters were used. The receiving units were also alerted.

The University Hospital in Fukushima received twelve patients with external contamination, and there was a prepared mobile facility for the care of contaminated people.

261 patients were admitted to the emergency room at J-village over the first ten months. All were men, 118 had traumatic injuries, 44 had suffered heat stroke and 8 were externally contaminated. Three of the contaminated were hospitalised (Table 4). 67 of the patients were transferred, two thirds by ambulance and the rest by helicopter. There was no permanent ambulance at the casualty department so this was requisitioned from the rescue services [13].

The general public that were evacuated from areas around the nuclear power plant were included in the 191,988 residents of Fukushima prefecture who were examined up until May 23, 2011. The threshold value was set at 100,000 cpm ("counts per minute") for whole body decontamination and 13,000 for "local" wiping and decontamination. 102 people had levels above 100,000 cpm and needed to be decontaminated. After this, most were well below the threshold value. Up until March 15 the local limit was 6,000 cpm. 162 people were examined and 41 were above the threshold value, of which five were decontaminated and taken to hospital. The threshold value was then raised to 13,000 cpm [19, ³³].

Tokyo's Rescue Services

The problems associated with cooling the reactors continued for weeks after the tsunami and, on March 18, Tokyo's rescue services were ordered to Fukushima. The assignment for the rescue services was to cool reactor 2 at Fukushima. To implement such a complex assignment requires careful planning and a systematic approach to safeguard the health of the staff and to solve the given task effectively. The firefighters who carried out the operation planned and prepared for more than twelve hours at their base before leaving for Fukushima. All feasible measures were practised before departure, and three times during the trip and at the site before the operation was performed. All rescue services staff were to be thoroughly familiar with the operation to minimise the time they were exposed to ionising radiation.

Before the staff were deployed to the contaminated area, a system was created to decontaminate them in a safe manner afterwards, in order to interrupt the exposure to ionising radiation. Before any staff were deployed to the reactor, a team monitored the status of the area and measured the dose

rate present in the area around the reactors. This was performed using a custom built fire engine with additional radiation protection which consisted of water and lead, as well as windows of leaded glass. However, the monitoring of the area revealed that the proposed method of running the hose and placement of pumping stations was not achievable and a new plan had to be worked out. The new plan meant that staff would be exposed to high radiation doses and it was difficult to calculate the exact doses for the operation.

In order to ensure that no one in the team was exposed to harmful doses of radiation, it was decided that each team leader would bring along a intensimeter and direct-reading dosimeters. Each team leader checked that no staff were exposed to high doses of radiation and the operation would be discontinued if anyone in the team was subjected to more than 100 mSv. The radiation levels in the environment in which the teams worked varied between 70 and 130 mSv/h, which meant that they could only work for short periods in the contaminated environment. Thanks to careful preparatory work and practising before the operation the highest measured radiation dose was about 30 mSv for operational staff.

Neutron radiation instruments were placed in strategic locations within the plant. All staff working in the area had also taken prophylactic iodine and were equipped with protective clothing – air packs and turnout gear. Inside the turnout gear the rescue services carried two layers of disposable coveralls with hood, a base layer and three layers of gloves. No rescue service staff were internally contaminated as a result of the operations.

Decontamination inspection was carried out after each operation and the staff had to take off their equipment in accordance with a predetermined procedure. After each step, all the radiation protection equipment was checked to ensure that the undressing procedure yielded the desired results, and as the last step individual doses were checked and listed using individual dosage cards.

Figure 11 Description of planned decontamination course according to the Tokyo rescue services.

Station 1		
Reception of staff	Removal of first pair of gloves Removal of helmet Wiping of mask Communication equipment is taken care of	1 person
Station 2		
Removal of outer layer of protective clothing	Breathing apparatus is placed in a plastic bag brought to next station Removal of turn out gear and boots Removal of disposable overalls worn under turn out gear Removal of second pair of gloves All material is placed in plastic bags	1 person
Station 3		
Contamination control	Contamination control of exposed response personnel If the response personnel are clean the breathing apparatus is removed and replaced with a simpler respirator. If the personnel are not clean they are sent back to Station 2	1 person
Station 4		
Final control measurements	Additional measurement of response personnel	1 person
Station 5		
Registration	Registration of individual dose	1 person

Response personnel wear the following gear during a response.

Layer 1

Turn out gear, helmet, breathing apparatus and mask, boots

Layer 2

Disposable overall with hood, thin gloves

Layer 3

Disposable overall with hood, surgical gloves

Layer 4

Underclothing, socks

After decontamination is completed the personnel still have layer 3 och 4 and receive a new pair of slippers and a mask.

All the staff who carried out work in the field underwent additional medical checks: whole body counting and a normal health check. The staff will also undergo follow-up checks.

Hospital Care

A total of 15 hospitals were badly damaged by the tsunami, which generated an increased burden on neighbouring hospitals in the area. Although the number of trauma cases was limited, the everyday needs for healthcare, especially non-communicable diseases of the aged population remained.

Red Cross Hospital in Ishinomaki

One of the hospitals in the tsunami peripheral region is the Red Cross hospital in Ishinomaki. The tsunami wave stopped just 500 metres short of the hospital closest to the most affected area. However, the municipal hospital with 200 beds was completely destroyed, and consequently the Red Cross hospital had to take over their patients.

Within an hour, the hospital had established a triage area with 450 beds and 120 doctors. Six of the hospital's 14 ambulances were destroyed which meant transportation to and from the hospital was a major problem. It took time before victims started arriving and during the first 48 hours only 19 injured were admitted. After one day, helicopters began arriving with patients, and within a few days the helicopters had made over 60 landings to transport patients to and from the hospital.

It was difficult to coordinate and manage the work because of a rapid turn-over of staff. The hospital coordinated the DMATs that were deployed to provide basic medical care to the 300 emergency camps that had been established. However, it took time before the hospital was given information about the location of the various camps, and before an epidemiological surveillance programme could be started including daily reporting of communicable diseases. One challenge was to ensure that water and sanitation systems were functioning properly, as initially neither worked. Many patients had diabetes, and other chronic illnesses and some required dialysis. The lack of medicines was a major problem, and special pharmaceutical vehicles were sent out to ensure that those with non-communicable diseases had access to medication. It was also difficult to take care of those evacuated from nursing homes and ensure that they received the care they needed in the assembly camps.

Healthcare and interventions to alleviate problems related to mental health were not integrated and coordinated with other healthcare efforts.

Medical Evacuations

During the first month, a total of around a hundred people were evacuated from the hospitals in the tsunami-affected areas to other hospitals in Japan with a higher level of care. The reason for the evacuation was to provide more advanced care for those with injuries and respiratory problems resulting from the inhalation of water, but also pregnant and dialysis patients needed more advanced care than that available in the area.

Evacuation was performed by the police, fire department and coast guard, and the coordination between them was deficient for example with difficulties in identifying the necessary transport capacity. A lack of fuel was also a problem for both the rescue services and individuals.

Handling the Deceased

In September 2012, 15,870 people were confirmed dead and 2,814 missing. The Japanese principles for the handling of the deceased are broadly the same as in Sweden. The Central Police National Police Agency (NPA) coordinated the identification work, but this was carried out in practice by the

local police authorities. NPA also has a central DNA database and all the other information concerning the identification process was also compiled centrally. The official numbers of identified and unidentified dead per police district are posted on their website. These figures are updated regularly [34].

Of the bodies that were found over the first six months, 80 per cent were identified by appearance, teeth or possessions that were on or in the body (e.g. driving licence). Several hundred were identified with the help of mobile phones that were found on the body, e.g. using the serial number and/or mobile operator. Autopsies were performed on all the bodies, which otherwise are not performed to any great extent in Japan. After the first six months, most of the deceased were identified in part with the help of DNA testing, as the bodies were in a condition that made visual identification difficult. 1,500 dentists worked in teams of three to identify the dead with the help of dental records. People who were missing relatives were also given access to morgues to see if they could identify any of the victims. Lists were also published on the Internet describing the appearance and physical characteristics as well as pictures of clothes and other items that were on the body [35].

The police also put up a database of DNA samples from family members of missing persons and even from some of those that had disappeared. If the residence was still intact, it was possible to take DNA samples from hairs, and if the missing person had donated blood they took any remaining blood from the Red Cross blood bank and made a DNA profile using it. On December 2011, 138 of the deceased had been identified by DNA samples alone.

There were not enough morgues for all the dead, but schools, sports halls and even a bowling alley were used.

The number found dropped significantly in September 2011, and since December 2011 fewer than ten dead bodies have been found per month. In February 2013, 1,314 people were still missing in the Miyagi prefecture.

Virtually all dead people are cremated in Japan. This was not possible immediately after the tsunami due to the lack of resources in the form of crematoriums and fuel. Temporary mass graves were used in several places.

A month after the disaster, searches began over a 10 kilometre wide evacuation zone around the nuclear power plant. Protective clothing was worn and any radiation was measured on the bodies found which were then decontaminated using water [36-38].

Efforts of Volunteers

NGOs are a regular part of the Japanese emergency preparedness process and many volunteers wanted to help in the disaster areas. Voluntary efforts consisted partly of professional and organised assistance where, among others, the Japanese Red Cross deployed 900 medical teams to work in the area. The Red Cross also organised more than 100,000 volunteers to support and assist the affected population. During the first year, a million volunteers were recorded in 100 centres in the three most affected prefectures, according to the NGO: The Council of Social Welfare. A variety of voluntary relief organisations were also created specifically for this disaster. Several of them were spontaneous volunteers who travelled to the affected area at short notice

to help. Families, relatives and friends also helped in the immediate relief efforts. Volunteer assistance continued up until the end of 2012 in the affected area.

Another example concerns the data of the authorities and Tepco, and the dissemination of forecasts and releases levels. The information was almost impossible to interpret for the layman due to it largely consisting of tables with numbers. Professor Ryugo Hayano, radiation physicist at the University of Tokyo, chose to convert these numbers into charts and pictures which he then published on Twitter. At most, he reached hundreds of thousands of people through his followers and their re-tweets.

International Relief Efforts

According to the Japanese Ministry of Foreign Affairs, there were 116 countries and 28 international organisations that offered assistance. Japanese authorities asked for search and rescue services from Australia, New Zealand, South Korea, UK and USA. However, significantly more countries sent relief teams and materials than requested. A total of 18 low, medium and high income countries sent search and rescue teams and medical teams. A further twenty countries sent material or financial support.

The Israeli military sent a field hospital which opened on March 29, 18 days after the tsunami, and could, among other things, offer surgery.

The US military has a relatively large presence in Japan. Immediately after the earthquake, humanitarian efforts were initiated through Operation Tomodachi, literally translated as “Operation Friend”. Thousands of soldiers were deployed over the first few months to help the population and authorities with rescue and relief efforts. The US assisted with about 16,000 US military personnel, 174 aircraft, 24 ships, 246 tonnes of food, and 31,500 tonnes of other supplies. The US also assisted with “Urban search and rescue” staff and Disaster Assistance Response Teams (DART).

Sweden's support for Japan initially consisted of members who were part of “assessment teams” from the UN and the EU. Based on the needs that these teams evaluated, Sweden chose to send blankets and rubber boots through the EU's support to Japan.

Primary Care

As many healthcare facilities were destroyed, primary care clinics were established in and around the camps. In addition to taking care of minor injuries, the principal task of primary care was to monitor public health in the camps and to take care of the standard healthcare for an ageing population. Special mobile pharmacies were also set up to deliver medications to victims.

Temporary Accommodation

The victims who either had their homes destroyed or had been evacuated due to radiation were housed in temporary accommodation. Initially, the assembly camps were based in schools and gymnasiums and the like.

Healthcare at these sites was improvised and in Ishinomaki, for example, healthcare was initially administered by the visiting DMAT staff. The

assembly camps have been gradually closed down but there are people still living in temporary accommodation even today.

The temporary accommodation are simple modules of approximately 25–30 m² built like blocks of small terraced houses with common assembly premises.

Table 4 Injured from emergency efforts at the nuclear power plant during the first 10 months [13]

Complaint	Quantity	Consequence				Quantity and type of life-saving measure
		Home	Admission	Deceased	Unknown	
Trauma	118	85	10	2*	21	2 (catheter cage arterial embolisation for the treatment of haemorrhagic shock due to splenic rupture and pelvic fracture)
Colds, fatigue	77	72	1	0	4	0
Heat stroke	44	39	1	0	4	0
External contamination	8	5	3	0	0	0
ACS, Acute Coronary Syndrome	5	2	2	1	0	3 (PCI for 2 and CPR Cardiopulmonary Resuscitation for 1)
Convulsions, loss of consciousness	5	1	2	0	2	0
Cerebrovascular disease	2	0	2	0	0	Unknown
Septic shock	1	0	0	1	0	Unknown
Asthma	1	0	1	0	0	0

* Two people that were missing after the disaster were assessed as traumatic deaths

Radiation Protection Measures at the Plant

The following section is based on several reports and assessments following the nuclear accident [19,20,39,40].

Workers from many different organisations have worked at Fukushima Dai-ichi, including Tepco staff and contractors, the rescue services, police, military and staff from various authorities.

Initially there was a lack of both electronic personal dosimeters and reading instruments, as many ended up submerged and destroyed when the tsunami hit the plant. Therefore, it was only the team leader who could be equipped with an electronic personal dosimeter, and doses were recorded manually on paper. Individual passive dosimeters (such as TLDs) were normally not used at the plant. On April 1, 2011 all workers at the plant could be equipped with an electronic personal dosimeter.

Table 5 shows the doses to workers at the plant over the first three months. Six workers, all employees of Tepco, received a dose exceeding the provisional threshold value of 250 mSv (effective dose) for rescue workers that the authorities had set on March 14, 2011. The maximum estimated individual personal dose was 670 mSv, i.e. below the limit at which acute radiation syndrome can usually be detected. The dose limit for staff involved in the

rescue work before the accident was set to 100 mSv. On November 1, 2012 the threshold value was set back to 100 mSv, with the exception of a small team of workers at the plant who were judged to have unique skills and could not be replaced at this time. However, on April 30, 2012 the threshold value was restored to 100 mSv for this group too.

The six workers who exceeded the limit received the single largest contribution to the dose from radioactive substances that they inhaled. All six worked in the control room for reactors 1 and 2, or in the control room for reactors 3 and 4 over the first days of the accident. For various reasons these workers had problems with their protective masks. Some had to take off their masks a few times to eat and drink. Others wore glasses, which the protective masks were not designed for.

The radioactive substances released from the reactors, both deliberate ventilation or accidental release, created a very difficult situation for rescue workers inside the plant. The explosions that took place in reactor 1 on March 12, reactor 3 on March 14 and in reactor 4 on March 15 spread radioactive material at the plant which deteriorated the working situation further. Very high levels of radiation were measured locally from the material disseminated at these explosions.

On March 15, 2011 the situation was so serious that Tepco evacuated all staff that were not essential for maintaining operations, and they were taken to the nearby nuclear power plant, Fukushima Dai-ni. After the evacuation, there were only about 70 workers left at the plant.

As of March 12 iodine prophylaxis was used for Response Teams, and as of March 13 iodine prophylaxis was ordered for all workers at the plant below 40 years of age. However, it was optional for older employees. In total there were around 2,000 workers who took iodine prophylaxis but no side effects have been noted. On October 12, 2011 all use of iodine prophylaxis ceased at the plant.

Reports consistently showed no cases of acute radiation syndrome among nuclear power staff, or in the general population. However, two workers were contaminated in the legs after they stepped into contaminated water in the turbine buildings. They were taken to a nearby hospital as there was a suspicion that they had received burns on their legs from beta radiation. They were then transferred to a specialist hospital (NIRS), which concluded that no burns had occurred. Treatment for cleaning contaminated skin was administered at NIRS and there is no data on permanent disabilities for the two workers.

Table 5 Doses to workers at the plant in March, April and May 2011.

Doses (mSv)	March [Qty]	April [Qty]	May [Qty]
More than 250	6	0	0
200–250	2	0	0
150–200	14	0	0
100–150	81	0	0
50–100	303	3	0
20–50	847	86	20
10–20	991	310	148
<10	1,471	3,064	2,553
Total	3,715	3,463	2,721
Maximum dose for each month	670.4	69.3	41.6
Mean dose for each month	22.4	3.9	3.1

Evacuation, staying indoors and iodine tablets

Figure 12 Figure for maximum propagation in the zones'



Source: Swedish Radiation Safety Authority

In total around 112 000 people were evacuated as a result of the nuclear accident. In the Restricted Area and outwards to 20 kilometres from the nuclear power plant, around 76,000 people were evacuated, and about 10,000 people in the Deliberate Evacuation Area which was introduced on April 22, 2011. A total of about 59,000 people lived in the Evacuation Prepared Area. This zone consisted largely of the area between 20 and 30 kilometres from the plant that was not included in the deliberate evacuation area. About 26,000 people responded to the call to evacuate voluntarily.

The Japanese government revised the evacuation zones on April 1, 2012 to a classification based on the potential dose from ground deposition over one year. In some areas, the dose from the ground deposition over one year is less than 20 mSv, and residents will receive help from the government to move back there. In areas where the annual dose from ground deposition is higher than 20 mSv evacuation is still recommended. The government will clean up and carry out repair work in these areas, with the objective that residents will be able to move back. In some areas, the annual dose from ground deposition is estimated to be higher than 50 mSv, and the government recommends that residents avoid these areas for a long time to come. The government will consider buying land and houses from residents in these areas if the current owners are willing to sell. Table 6 below shows the safety precautions that Japanese authorities took in the first year after the nuclear accident.

Table 6 Safety precautions to protect the general public during the first year.

Date	Measure
11/3-11	In the evening, evacuation was recommended out to 2 km. Within half an hour, evacuation is amended out to 3 km and an order to stay indoors between 3 and 10 km.
12/3-11	Early in the morning, evacuation was recommended out to 10 km. At noon this changes to evacuation out to 20 km.
15/3-11	In the morning it is recommended to stay indoors between 20 and 30 km.
25/3-11	Voluntary evacuation is recommended between 20 and 30 km.
22/4-11	It is prohibited to be within a radius of 20 km of the plant - "Restricted Area". New zones are introduced - "Deliberate Evacuation Area" and "Evacuation Prepared Area". The order to stay indoors between 20 and 30 km is lifted.
16/6-11	Policy for "Specific Spots Recommended for Evacuation" is introduced.
30/9-11	"Evacuation Prepared Area" is removed.
1/4-12	New zones are introduced, "Restricted Area" and "Deliberate Evacuation Area" are reduced.

On March 16, the Japanese authorities decided to distribute and recommend the taking of iodine tablets to those who were evacuated from the zone out to 20 kilometres from the nuclear plant. However, nobody took the iodine tablets as a result of this recommendation as the evacuation of the affected area was already over when the decision was to be enforced. Four municipalities decided on their own to distribute and recommend the taking of iodine tablets, while two municipalities distributed iodine tablets to residents and one municipality distributed iodine tablets to the evacuation centres. There is no reliable data confirming how many people actually took iodine tablets as a consequence.

At the end of March 2011, it was time for the spring half-term break for schools in the Fukushima prefecture. A discussion took place as to which

schools should open again after the break and if there was reason to limit the time children could be out in the playground. On April 19, the central authorities decided to restrict the time spent outdoors in schools where the dose rate was higher than 3.8 $\mu\text{Sv/h}$, which corresponds to an annual dose of 20 mSv. This decision came shortly before the deliberate evacuation area was established on April 22 on the basis of the same dose rate value, and it resulted in strong protests from the parents. On May 27, 2011, the authorities changed focus: the goal would be that school children could be exposed to a maximum of 1 mSv in 2011. Dosimeters were distributed to schools in the Fukushima prefecture and the government offered financial assistance to clean up school playgrounds with a dose rate exceeding 1 $\mu\text{Sv/h}$ [19,20].

Emergency Communications

The consequences of the triple disaster persisted for such a long period that it was difficult for the Japanese authorities to absorb and comprehend the whole situation. The initial information went out to the general public just a few hours after the earthquake had occurred. However, this was not followed up with any information on the development of events. The authorities prioritised detailed and accurate information to the general public and the media, especially the rapid sharing of information that perhaps could not have been fully verified.

An example of communication that did not work fully is when explosions began to occur at the site of the nuclear accident. On March 12, after the hydrogen explosion at reactor 1 had taken place, the Japan Atomic Energy Agency (JAEA) announced that the sequence of events for the accident at the reactor was 4 on the INES scale (International Nuclear Event Scale). On March 14, reactor 3 exploded. As a consequence of this, the French equivalent to SSM held the opinion that the accident should be classified as a 6 on the INES scale. However, it would take another four days until March 18 before JAEA chose to reclassify the accident on the INES scale. It was then decided that the situation at reactors 1, 2 and 3 corresponded to a 5 on the scale. Reactor 4 corresponded to a 3. Not until April 12 did JAEA decide that the accident corresponded to a 7, the highest level, on the INES scale.

The residents in the area around Fukushima Dai-ichi were given inadequate information about the nuclear accident. Local authorities and the police were the main source of information for many people, as they were on site in the affected areas. Many people felt that there was an information vacuum and instead sought information from other channels, and there was a long list of experts, both self-proclaimed and genuine ones, who expressed their opinions independently of the authorities. In some cases, their messages were inconsistent with the picture that the authorities later communicated. When the authorities eventually began disseminating information, it was not designed for the target groups, which made information difficult to access.

Individual experts took their own initiatives, which in some cases were eagerly received by the general public. One such example is the expert who interpreted information regarding radiation levels and made this available to the general public through Twitter.

The authorities then began to stop disseminating information altogether. They then gave information that was difficult to understand and which did

not always correspond to what other sources had been communicating at that time. This meant that the authorities lost the trust of the people and future messages were met with suspicion.

Recovery

Medical Monitoring

The Japanese authorities are conducting more extensive monitoring of the health of the population after the disasters, including:

- Fukushima health management survey program (Fukushima Medical University)
- a long-term monitoring process of the population in the Miyagi area (Tohoku Medical Mega Bank), divided into several cohorts
 - “local residents cohort”
80 000 residents in coastal areas in Miyagi
 - “three-generation cohort”
70,000 people (children, parents, grandparents)
 - “local children cohort”
monitoring of all school-age children
- monitoring of people who work with relief efforts and clean-up at the Fukushima nuclear power plant (Ministry of Health, Labour and Welfare).

Tohoku Medical Megabank Project

Tohoku University School of Medicine has been tasked by the Japanese government to implement the ambitious Tohoku Medical Megabank project. The project is to lead to innovation in the medical field by establishing a new biobank that will provide a platform for large-scale cohort studies, with monitoring of those affected by the disaster in Miyagi and Iwate. The project is also to encourage economic growth in the region.

Even before the disasters in 2011, there was a lack of doctors in the Tohoku region, where all the three prefectures of Iwate, Miyagi and Fukushima are situated. This shortage was particularly evident at a local level and in the more remote parts as it was considered as a less attractive career path. In connection with the earthquake and tsunami, six major hospitals in the region suffered extensive damage which meant further restrictions on healthcare resources. The government wants to make a clear commitment to the region in rebuilding healthcare services from an already strained level, and the aim is to reinvigorate the region at large, including those outside of healthcare.

The project includes

- building a large biobank
- medical support to disaster victims
- creating a good research environment.

The goal is to rebuild the destroyed hospitals and health services in the affected coastal areas, encourage doctors to work in the affected areas and provide direct support to healthcare for residents in the affected areas. In addition, the project could lead to the increased recruitment of healthcare staff in the region, opportunities for advanced training for highly specialised medical staff and increased job opportunities in related fields.

The biobank is to include blood (“whole blood”), serum and DNA (“genomic DNA”). The project can also gather additional information by having access to patient records and through a questionnaire based on lifestyle, psychological conditions and experiences from the disasters. The project is based on two cohorts:

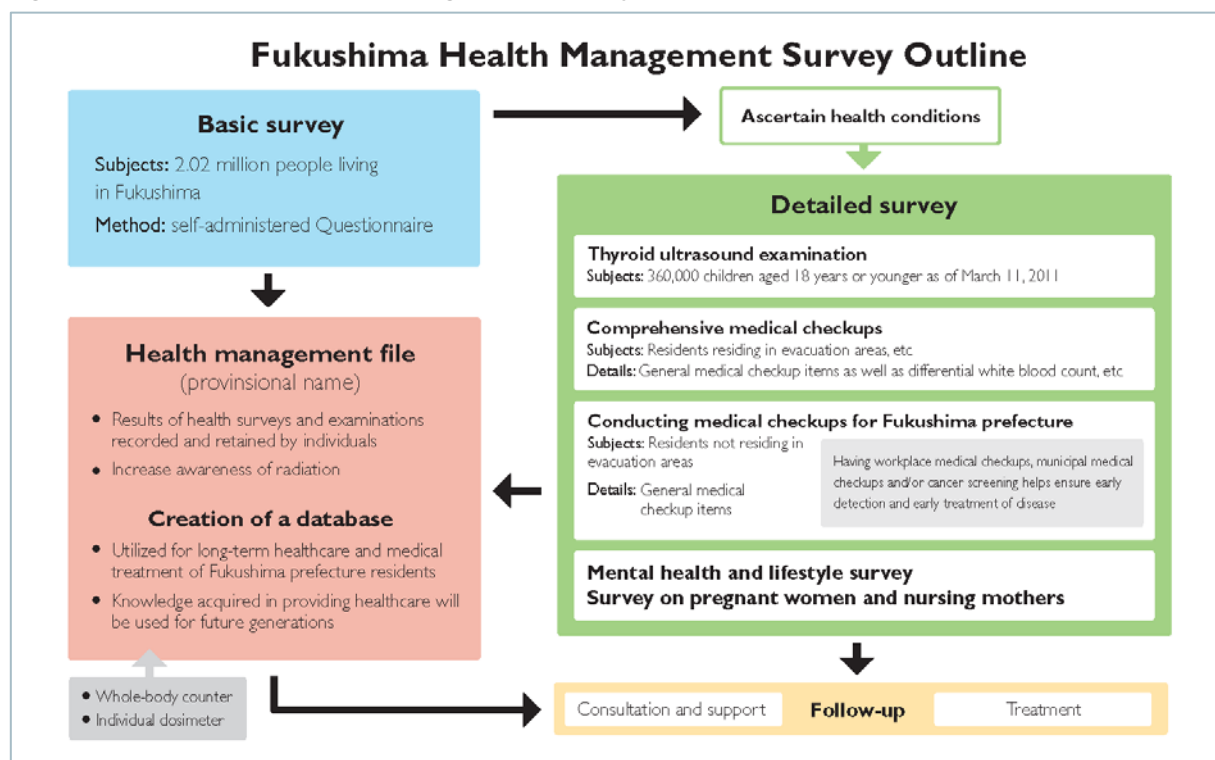
- “local residents cohort”: 80 000 residents in coastal areas in Miyagi
- “three-generation cohort”: 70,000 people (children, parents, grandparents).

The project also takes into account a third cohort of school-aged children from the affected areas - “local children cohort”.

Monitoring of Residents in the Fukushima Prefecture

“The Fukushima health management survey program” is a blueprint for lifelong health monitoring of two million people in the Fukushima region. The University Hospital in Fukushima is the coordinating unit for the survey, which contains two main parts: a basic survey for all residents and targeted surveys for certain populations (Figure 13).

Figure 13 Fukushima Health Management Survey



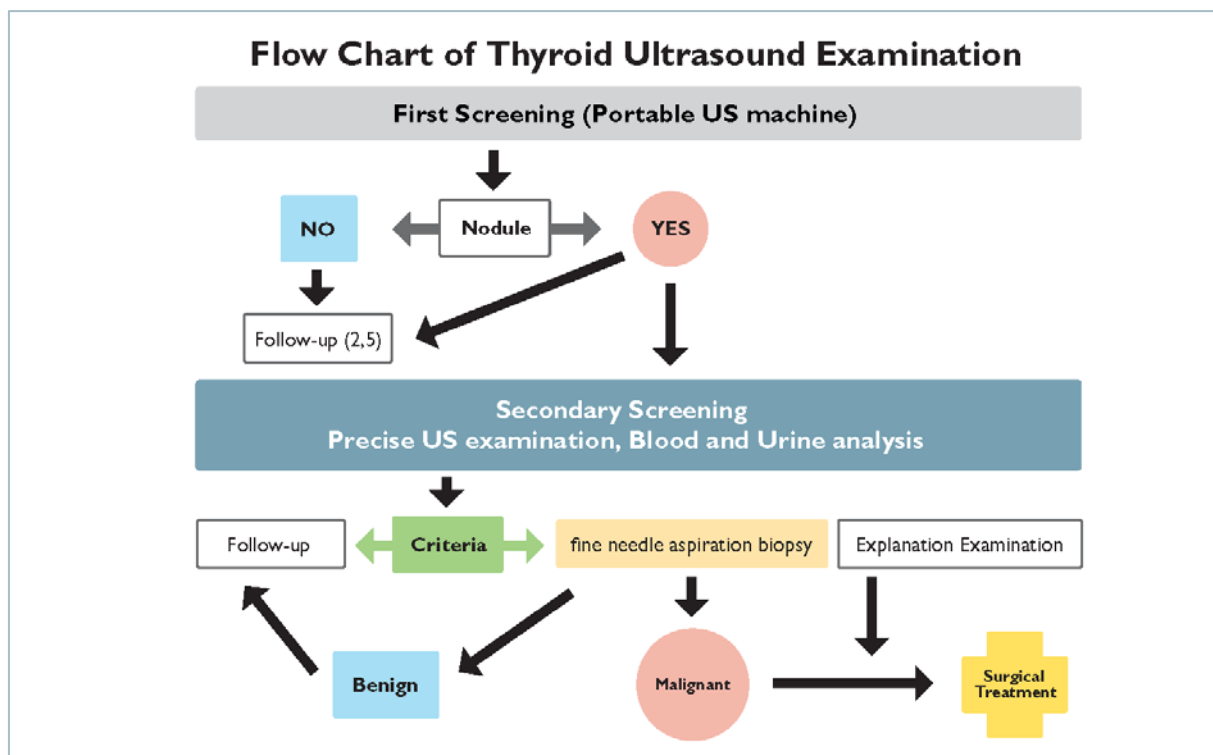
Source: Fukushima Medical University [41]

The basic survey is aimed at determining the estimated radiation exposure for each individual depending on where they were at the time of the accident and how they moved about. Each person must answer a series of questions that help to identify how long he or she has been residing in the contaminated areas. This is supplemented with distribution maps with information on radiation levels at different times, and can thereby estimate the radiation exposure for each person.

The targeted survey is designed for children (360,000) and women who were pregnant at the time of the accident (10,000) including a special survey of their then unborn children. All children are regularly examined by ultrasound of the thyroid glands to see if there is anything abnormal. The first survey is to be conducted within three years of the accident, and then from 2014 onwards in a special screening programme. If anything abnormal is identified, the survey will continue in an extended form (Figure 14).

The survey also covers a lot about mental health and lifestyle for those who were evacuated, where the aim is identify symptoms of stress, anxiety problems and post-traumatic stress disorders. Those who lived in the evacuation zone, and those living in some areas north-west of the nuclear power plant but outside the evacuation zone (the basic survey showed that these also had higher radiation doses), are also offered an expanded health survey (210,000 people). Everything is processed in a large database for future research and monitoring. Some early results have been reported and individual articles published.

Figure 14 Monitoring of the thyroid glands of children



Source: Fukushima Medical University [41]

Everyone who has participated in the work on the nuclear power plant and received radiation doses above the regular threshold value is monitored separately, and the dose is estimated through the monitoring and potential surveys. NIRS coordinates this work.

Only 23 per cent of the population have answered the basic survey to make a dose estimate. The response rate was higher in the worst affected areas, and women, children and the elderly have a higher response rate. Generally, low radiation doses have been calculated. In the north (Kempoku) and central (Kenchu) areas more than 90 % of the respondents had received a dose of

less than 2 mSv, while in the remaining areas more than 90 % had received less than 1 mSv, except in Soso where 78 % had received <1 mSv.

The most recent report of the thyroid gland study involved 76,357 people (82.5 per cent of those called) 0-18 years who were called up to October 2012. Up until September 2012, changes had been seen (nodules) in 538 children (0.9 per cent). Over half of these were investigated further due to the extent of the change (> 10 millimetres). However, as many as 58 per cent of all those surveyed, had cysts (fluid-filled cavities), but 82 per cent had no cysts or cysts that were less than 3 millimetres. These results are reported regularly and are the source of a lot of speculation in social media.

For the study of mental health, the response rate was 44 per cent. Of those assessed, 5 per cent needed psychosocial support and they were contacted by telephone by a psychologist or district nurse. They were divided into three groups according to severity and offered support if they so desired or if they had more severe symptoms. 60-80 % of these received support [42,43].

Monitoring of People who Work with Decontamination at the Fukushima Nuclear Power Plant

NIRS coordinates medical monitoring of those who work and have worked with the decontamination work at the Fukushima nuclear power plant. The scope of the monitoring depends on the estimated dose and a database has been created for this. The medical monitoring applies to the following groups:

1. Those who work and have worked at the plant, employees of Tepco and contractors
2. Staff in the emergency services, police and self-defence forces
3. Officials from local authorities.

For *group 1*, the doses and the results of medical tests are reported to the Ministry of Health, Labour and Welfare. This is mandatory and a legal requirement. The database is under construction. For *groups 2 and 3*, the employer is responsible for healthcare but does not report any results or monitor any particular team for follow-up [⁴⁴].

Decontamination

Environmental Clean-up

The decontamination work is based on two different principles. The first principle, “Basic Principles for decontamination”, was adopted by the Cabinet Office in November 2011 and consists of four different themes that will govern what will be cleaned up and at what dose. The principle also describes how to store waste following decontamination without describing the technical aspect of the work. This principle is the overall focus of the decontamination work [45].

There are the four basic principles:

- Decontamination is to be prioritised in areas where human health can be protected. In these areas, the decontamination plans are established and the plans should take into account dosage measurements that are carried out in the areas. The areas where children live should be given special priority.
- In the areas where the annual dose to the population is less than 20 mSv, the goal is to reduce the additional dose to the population to 1 mSv/year or less.
- In the areas where the additional dose to the population is more than 20 mSv/year, the goal is to reduce the annual dose gradually. These areas require a long term commitment.
- The waste generated from the decontamination work must be dealt with and disposed of in a safe way.

In January 2012 the Ministry of the Environment decided on how the basic principles should be fulfilled. The decision taken entailed the following targets for the years 2012 and 2013:

- In the areas where the dose was less than 20 mSv/year after the accident this must be reduced to ensure that the extra dose to the general public is less than 1 mSv/year.
- In areas where the extra dose is 20-50 mSv/year, the goal is to reduce the level in 2012-2013 around homes and farmland to below 20 mSv/year.
- The areas where the radiation levels are above 50 mSv/year will be used for various kinds of research and development projects, the results of which will be used in the continued work on the clean-up.

The ultimate goal is to reduce the extra dose to the general public to less than 1 mSv/year.

In order to achieve these objectives, the authorities in Japan have chosen to share the responsibility for the decontamination work among different operators. The areas that are most contaminated, known as “special decontamination areas”, the Japanese government is responsible for. This means that national authorities are responsible for developing decontamination plans, and for working according to these plans. In areas with less than 20 mSv/year, the municipality is to be responsible for preparing decontamination plans and for ensuring that work is carried out according to these. The municipality's decontamination plan is to be discussed with the regional authority before the work begins.

During the decontamination work, measurements are taken to make sure the decontamination is progressing according to plan until the target is achieved.

In Japan it has been decided to decontaminate roads, public places and buildings, as well as residential buildings i.e. houses and gardens. Additionally, the area 20 metres out from site limits is being decontaminated and out from the roads.

For the authors, it remains unclear how the decontamination goals are linked to the available budget, but large amounts of money have been assigned to conduct decontamination work.

Each house that is decontaminated takes about 30 “man days” (one man day is the work a person does on a weekday) to implement and creates about 40-60 m³ of waste. The waste problem is, and will remain, a major problem for Japan. Japan has chosen to store the waste temporarily in close proximity to the areas being decontaminated. How the future solution for disposal on site will look and the construction of the plant had not been decided when the team visited the area. One problem is that other municipalities and regions do not want to take materials from the area regardless of whether they are contaminated or uncontaminated.

Discussion

The authors of the report find it difficult to see how any other country would have been able to handle the kind of triple disaster that struck Japan in March 2011 in a significantly better way than Japanese society managed, despite some flaws. The country is relatively often subject to earthquakes and therefore there is a high level of preparedness and capability to deal with such incidents, which was also the case on this occasion. There is also planning for tsunamis, and a relatively good capability to deal with this type of disaster. Furthermore, Japan, as other countries with nuclear power, has a plan in place for any serious incidents within the radio-nuclear area. The Japanese emergency management system is well-developed and structured, with good access to resources in terms of both staff and material. However, the tsunami that hit Japan in March 2011 was larger than many people could have imagined, and the medical consequences were different than those after the earthquake in Kobe 1995 that was the last disaster that struck the country. The biggest medical challenge at that time involved bodily injuries, and led to the formation of DMAT teams. The effects of the earthquake led to such enormous damage that communication systems did not work which consequently undermined the preparations.

In both the Japanese and the Swedish emergency management systems, there is a division of responsibilities between central, regional and local levels. Japan also has a strong element of national operational emergency management following a disaster, which in some cases could facilitate overall decisions regarding the reallocation of resources.

The Swedish emergency management system is based on the principles of responsibility, equality and proximity. It is a strength that the operator who in everyday life is responsible for an activity – and therefore is fully versed in the mandate, role, responsibilities and legal conditions – is also responsible in an emergency. The system puts high demands on the interaction between operators, both in terms of preparation and in the management stage, to be able to act based on the most accurate and comprehensive picture of the situation as possible.

The emergency preparedness ordinance [⁴⁶] clearly stipulates in Sweden that the authorities concerned must cooperate both in planning and management phases of a serious incident. Generally, however, the authorities need to develop their coordination capabilities.

The Safety Situation and Responses for Swedes Living Abroad

Accidents where people risk acute life-threatening injuries from ionising radiation are generally associated with nuclear power plant operations. Today there are about 500 nuclear reactors that have been built or are being planned in some 30 different countries [⁴⁷]. A large number of radiation sources are also used on a daily basis in areas such as industry and healthcare that, following an accident, could cause severe, acute health effects. IAEA records around 50 or so radiological de facto incidents/accidents of varying severity

internationally each year. In addition to this, it is evident that a catastrophic threat scenario is provoked from the real existence of nuclear weapons in several countries. Although the risk of very serious radio-nuclear incidents (accidents, acts of terrorism, war) is limited, the potential “worst-case” scenarios are frightening. The threat scenario may have trans-boundary consequences. Swedes are a travelling people and therefore risk being exposed to radio-nuclear incidents in several places around the world. The capability of deploying Swedish personnel to assist in a situation where many people who are resident in Sweden suffer a serious accident or disaster abroad, known as a Swedish Response Team, is already in place today. There are many skills involved here including medical.

CONCLUSIONS: The risk of radionuclear incidents occurring in the world made itself evident in the context of the nuclear power accident in Japan in 2011. The Swedish medical expertise on preparedness and management of these incidents should be strengthened, including the Swedish Response Team.

Planning for Major Incidents

Experiences from the triple disaster show that even a society with a well-developed disaster recovery plan and good resources can be placed in a situation that is completely unexpected and difficult to manage. It is important that disaster plans are designed to provide flexibility in dealing with a serious incident. This is especially important for serious incidents which are very extensive or complex. Society must also determine the level of its planning and prevention work. One example is that the protective walls against tsunamis were in this disaster too low in many areas. A society needs to decide at what level their prevention efforts should be. The challenge is to find the optimal balance between risk and cost efficiency.

Sweden has established systems for disaster planning in different activities and at different levels of society, and these are based, among other things, on the risk and vulnerability analyses that have been conducted. A generic emergency plan is often combined with specific plans for certain scenarios. However, disaster planning for several major incidents occurring simultaneously or sequentially is less common. The sequence of events with the earthquake, tsunami and nuclear accident is hardly likely in Sweden, but it is conceivable that other factors together could lead to something similar happening here too.

CONCLUSIONS: Protecting society from serious incidents that occur very rarely requires trade-offs between risks and costs, and what society should invest in. This is particularly evident in a Swedish context, where we are rarely subject to major disasters. How prepared should society be, and what will it cost? Swedish emergency preparedness also needs to improve its ability to cope with multiple, simultaneous incidents. The combination of disasters that occurred in Japan is unlikely in Sweden. However, there may be other combinations that could cause equivalent problems but may be difficult to identify. Stress testing of society's emergency preparedness measures could then be a good tool in identifying any weaknesses.

The nuclear disaster in Japan shows that such accidents may lead to an extended crisis where the emergency situation continues for weeks or even months or years. This in turn leads to significant pressure on the organisations that are handling the accident and its consequences. Organisations with responsibilities in nuclear energy preparedness therefore need to develop plans for managing protracted sequences of events.

The needs that arise in connection with a serious incident or disaster depend on various factors, not just the type of incident, but also the make up of the affected community. Following the triple disaster, there were relatively few people that were injured by the earthquake and tsunami, but problems soon arose for those with chronic diseases. This group was large because Japan has a high proportion of elderly people in the population, especially in rural areas. A situation arose where many people were left without their daily medications. In addition, a large number of healthcare facilities were destroyed, and consequently patients' medical records too, making it difficult and time consuming to reconstruct the illnesses and medical needs of patients.

CONCLUSIONS: The disaster medical planning needs to take into account that different disasters create different acute illness needs, but that chronic conditions among the population will continue to need to be taken care of with perhaps partially eliminated infrastructure. This means that the greatest needs after a disaster are not necessarily those created by the direct effects of the disaster itself but rather indirect effects caused by health service infrastructure destruction leading to reduced health service coverage. To mitigate such effects disaster medicine skills are required.

Medical Evacuation

It is important that there is a prepared capability to evacuate. This applies to both deliberate and emergency evacuations of hospitals and assisted living facilities in the municipalities, and the evacuation of residents such as those in the vicinity of nuclear power plants.

An emergency evacuation of a hospital or an assisted living facility could lead to problems such as medical record entries even in Sweden. Swedish healthcare is highly digitised, which may provide a sense of security but also poses some challenges if these systems, including back-up databases, are knocked out. This calls for reliable backup systems and procedures such as medical record printing or to otherwise ensure that current medical information about patients is available. In Sweden there are basically only electronic medical records, but usually there are backup systems in geographic proximity. However, this information is stored in each county, which means a major natural disaster could erase the records if both the regular database and the backup database are affected. There is currently a project in progress to facilitate access to patient records from all counties. The Swedish Association of Local Authorities and Regions (SKL) is to initiate a system of backup storage of information in a “sister county” that is located far away [⁴⁸].

CONCLUSIONS: It is a major challenge to evacuate people effectively and safely from hospitals and nursing homes. Clearly defined and elaborate plans are called for that must also involve training. This is especially relevant for evacuations involving vulnerable groups, such as critically ill patients in hospitals, children, the elderly and individuals requiring special care in nursing homes, etc. The experiences from Fukushima underline the importance of making well balanced risk-benefit analyses of an evacuation, i.e. carefully weighing the risks involved in a fast evacuation of specific groups of the population (as described above), against reduced exposure to radiation and thereby reduced long-term health hazards that an evacuation can entail.

Exercises

Exercises are a valuable tool for the affected operators and individuals to be better able to deal with a serious incident. The importance of emergency management exercises has been mentioned in several contexts, including after the triple disaster in Japan, but also after the bombing in Oslo and the mass shooting at Utøya [49]. This could apply to exercises of the individual operators in terms of disaster or emergency management plans, major collaboration drills or escape and evacuation drills. In Japan, regular exercises are held with the population under different scenarios as there are plans for quickly evacuating homes and other buildings, establishing relief efforts and taking care of the injured. This is in many ways a strength, and the general public is aware that they are living in a danger zone when it comes to natural disasters. However, it has been argued that the exercises to some extent became routine and that too much exercise can cause them not to be taken seriously.

Evacuation drills before a nuclear accident or a dam failure, for example, at any of the hydropower plants requires greater involvement from the residents who are actually being evacuated. Additionally, it is advisable to start by training the staff responsible for implementing operations.

CONCLUSIONS: Exercises must be conducted so that they are perceived as relevant by the participants. It is important to focus the exercises to hone the particular practical skills that may be required, such as in a nuclear accident. A special aspect about exercises for healthcare professionals concerns taking into consideration the risk of the fear of staff being injured in connection with the handling of suspected or actually contaminated patients following radio-nuclear incidents. In the context of Fukushima, as with many completed exercises, examples of intense fear of radiation were noted that led to the risk of seriously late or no medical management at all for patients with intensive care needs. This problem should be addressed more clearly in future planning.

Reinforcement Resources

After the Kobe earthquake in 1995, a build-up of reinforcement resources began in Japan.

Disaster Medical Assistance Teams

DMATs are tailored for shorter relief efforts (no more than 72 hours), but in connection with the disaster of 2011, the needs were more long-term and after a while it was largely about primary health care. The teams were mainly focused on the care of those injured by the earthquake, but they were primarily tasked with taking care of other needs, such as reconstructing patients' medication needs and preventing the spread of infections and treating them outside of the hospital environment. Many teams were deployed to the affected areas, and this proved to be a challenge for the existing organisation to use teams in the best way.

The need for Swedish medical response teams has been discussed. In the 90s there were “trauma teams” that consisted of a number of surgeons, anaesthetists, surgical and anaesthesia nurses from a dozen hospitals around Sweden. The problem was maintaining skill levels, and that the teams were split up, but above all it was unclear what they were for. The need for specially trained “DMATs” is debatable, but their brief needs to be clearly defined and their skills and availability need to be regularly reviewed. Such a “function” requires a clear role and resources in order to ensure that they are available on the day they are needed.

CONCLUSIONS: The ability to quickly mobilise materials for medical staff for response efforts in disaster hit areas could be an important disaster medical resource in well-defined contexts. However, this requires clearly defined roles and management as well as regular exercises. The value of such a resource must be weighed against the costs.

Radiation Medicine

Japan is well organised to take care of radiation-exposed patients at a primary, secondary and tertiary level, where the tertiary level is the highest medical level for radiation emergency medicine.

If a nuclear or a radiological accident should occur in Sweden, all emergency care hospitals will be receiving hospitals. The alternative is that a hospital assumes responsibility for radiation emergency medicine (equivalent tertiary level), with a centralised knowledge base, preparedness and planning. This would strengthen the ability of the Swedish healthcare and nursing service to take care of patients exposed to radiation. This hospital would be able to offer advice to other hospitals (equivalent to secondary level) and take care of some patients exposed to radiation.

CONCLUSIONS: Classification into primary, secondary and tertiary hospitals would be of great value to Sweden. This provides the opportunity to practice and maintain skills at each level. Hospitals that may be expected to take care of contaminated or suspected contaminated patients need to invest in continuous training and exercises for their staff. The project goals for activities should also include help in reducing the fear of radiation. Ahead of rare but potentially devastating disasters, international medical preparedness collaboration is of major importance – which particularly applies to radio-nuclear incidents. Sweden is already participating in these kinds of international collaboration projects but this collaboration can be further developed and concretized.

Receiving Assistance

A large number of countries offered Japan help in various ways after the triple disaster, and they also accepted a great deal. However, some of those responsible in some affected areas considered that they did not have the capability to receive outside help, as it would require too much time and effort that was needed elsewhere. The additional reinforcement resources therefore needed to be fully self-sufficient so as not to deplete scarce commodities, such as fuel, food and water. In Japan, the healthcare authority was tasked with determining the need for medical assistance from abroad. But in this case, decisions were taken at a higher political level as it was considered too sensitive to refuse medical aid shipments, even though they were not needed [⁵⁰]. It was essential that staff from other countries were able to communicate in Japanese. Other resources that were sent, such as food, needed to be adapted to the needs and local culture making them useful to recipients. Among the aid delivered was food that the Japanese population is not accustomed to eating or preparing. It is also important that there is a plan to receive domestic reinforcement resources to be able to integrate them with the existing staff.

Sweden is used to deploying reinforcement resources to other affected countries and is used to the UN system, which is often coordinated by the Swedish Civil Contingencies Agency (MSB). However, it is rare that Sweden receives reinforcement resources. In 2012, the Commission for International Support in Times of Emergency submitted its report [51], which pointed out that there are few real barriers to receiving help. However, the report proposed a number of improvements such as skill enhancing measures, expert support, mapping of the arrival, departure and reception sites, logistics and transport strategies and reinforcement staff (including voluntary resources).

In Sweden you can go far with English, but Swedish may be required to read and receive information on various relief efforts.

CONCLUSIONS: In connection with major disasters, it is not uncommon for other countries to offer to send reinforcement resources. It is important that the affected country clearly indicates the types of needs that have to be covered along with the conditions under which the resources can be received in order for these resources to be useful. Receiving resources that are not essential can drain the energy and assets that are needed for other tasks.

Volunteers

In Japan many valuable contributions were made by NGOs, and many private individuals, and these can also be a valuable resource in Sweden. After the tsunami of 2004, a number of Swedish “spontaneous volunteers” were on location in Thailand to make important contributions in the early days before the institutional aid got started. In order for contributions from private individuals and NGOs to be as useful as possible, the relevant operators must be prepared to receive them. Rejecting them creates other problems such as dissatisfaction and disappointment in that offers of help are not being accepted.

CONCLUSION: It is important that there is a plan that takes into account voluntary initiatives and that there are procedures in place to receive contributions from private individuals and NGOs.

Communications – Alarms and Technology

In all countries, the normal alerting of emergency response staff is based on a functioning infrastructure for communication systems. In the initial phase the alerting procedures worked, but the tsunami wiped out large sections of the radio and telecommunications systems. Since communications were down for several days, the relationship between management and operational staff was complicated.

There was access to satellite phones, but for various reasons it was not fully operational. This may partly be due to the technology not working properly, and partly because the users were unaccustomed to using the telephones. However, the Internet functioned relatively well during the whole period, and was an option when the telecommunications were not working.

In order to deal with a situation without regular telecommunications, it would have helped if the opportunity was available to build up temporary mobile networks, particularly in the initial stage.

The PTS (National Post and Telecom Agency) has funded a number of mobile base stations in Sweden. They are located at the telecom companies to be deployed by them if the network capacity goes down. They are packed in containers for quick and easy transport [52].

CONCLUSIONS: Communication is often a problem in disaster areas. The response team must be able to work independently along a given direction, without continuous communication. Other tools, such as Rakel (the Swedish national TETRA-based digital communications system) or satellite telephones, are available and can be used by everyone involved in the rescue efforts.

Communications with the General Public and Media

Experiences from the triple disaster demonstrate the challenges that exist when it comes to information and communications with the general public and the media in a disaster situation. The hesitancy and eventual reactive posture of the Japanese authorities shows how important it is to communicate even – and perhaps especially – in situations where there is no reliable or adequate information. The general public and the media will otherwise seek information from other sources that may not always be completely reliable, and it is then difficult to reclaim the microphone. Communicating uncertainty is difficult, but it is important to retain the confidence of the general public.

It is important to choose the right channels, make trade-offs between quality assured and timely information and develop targeted messages. The responsible authorities must strike a balance between communicating possible risks based on insufficient information and not to scare the general public unnecessarily.

It is necessary for those involved in the Swedish emergency management system to work together to create a common situational awareness and, based on this, send out a comprehensive message.

When a serious incident occurs, such as a nuclear accident, other countries and international organisations soon require information about the incident. Operators with emergency management responsibilities should therefore ensure that they can provide information in English to ensure that non-resident operators, who do not understand how Sweden works, get a comprehensive and accurate picture of the situation. The above requires regular exercises and that prepared statements already exist and are up to date, and are ready to be quickly disseminated

CONCLUSIONS:

Quick and proactive communication with the general public is a key factor and may mean the difference between trust and lack thereof. If the authorities do not inform, citizens will seek information from other sources. A clear communication plan must be in place for how to communicate with the general public and the media through traditional and social media. Preparations must be in place for access to skilled spokespersons.

The nuclear disaster in Japan shows that lack of knowledge about radiation and its risks gives rise to fear. The accident also shows that it is difficult to try to put the radiation risks into a context when the accident has already happened. Basic training about radiation should be included in regular school curricula at both primary and secondary level. Residents near nuclear power facilities should also receive additional information since they may be affected most if an accident should occur. Knowledge regarding the medical effects and treatment of acute radiation incidents is also inadequate in Swedish healthcare. Training initiatives are therefore primarily needed in emergency care and medical units that provide direct care responsibility for patients affected by radiation.

Restoration and Follow-up Work

The people who were evacuated and are now living in temporary accommodation are frustrated that some of the promises of the authorities have failed to materialise. These promises include the reconstruction of dwelling houses which, for reasons of safety in certain areas, the authorities have had to revise.

Many elderly people who were having problems even before the disaster are likely to have little chance of moving on to other accommodation. The situation is also difficult for people who had mortgages on their homes but lacked insurance that provided protection in the event of natural disasters.

CONCLUSIONS: It is very important to have good co-operation and dialogue between government authorities and all others concerned regarding constructing living accommodation, awarding compensation for loss of income etc. Otherwise there is the risk of individual participants making promises which at a later stage cannot be fulfilled.

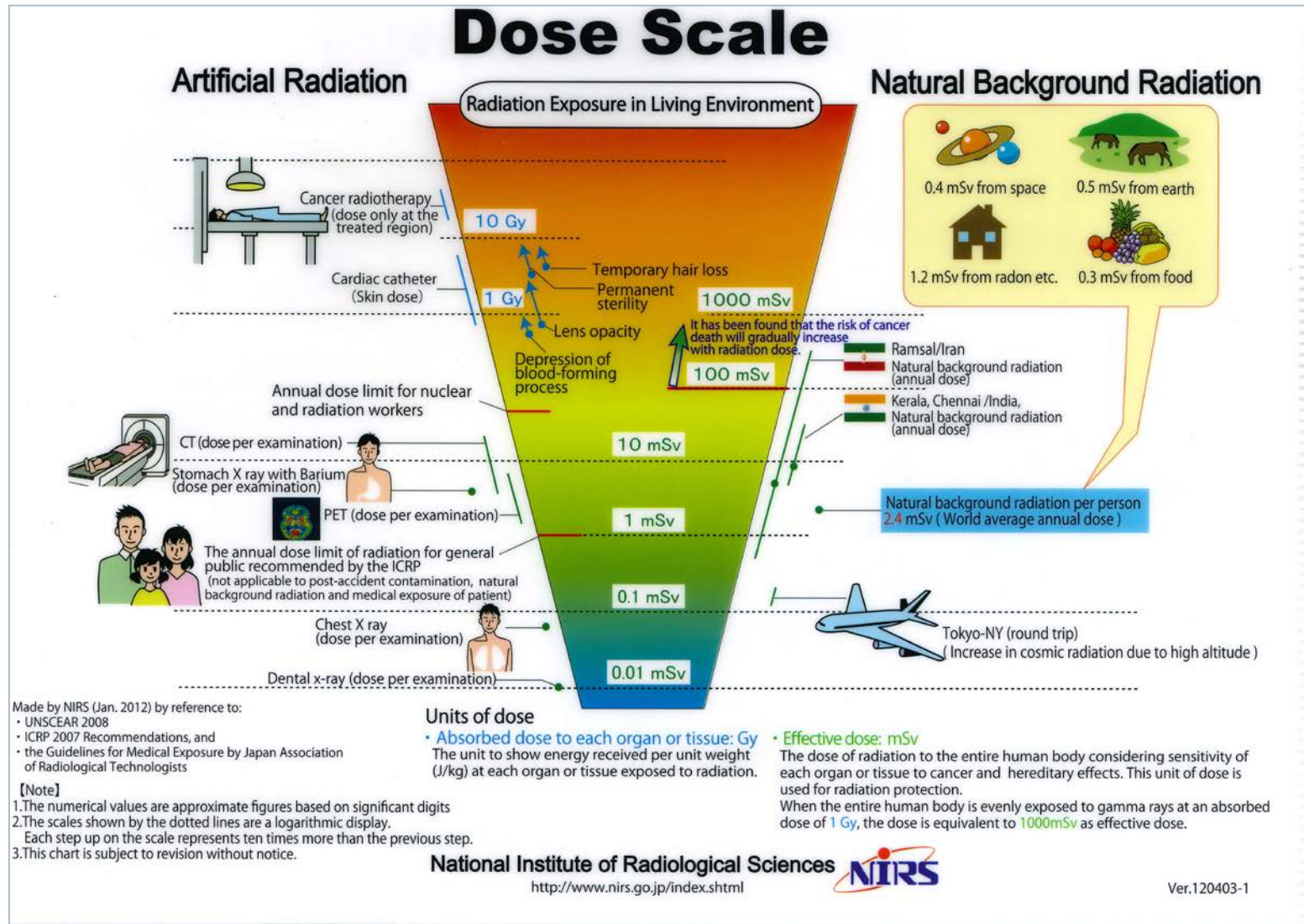
Visitor programme

	Mon, 10 Sept		Tues, 11 Sept		Wed, 12 Sept	Thurs, 13 Sept		Fri, 14 Sept			
	MEDICAL	DECON.	MEDICAL	DECON.	JOINT	MEDICAL	DECON.	MEDICAL	DECON.		
					Meet at lobby (7:30)		Lobby (7:00)	Lobby (7:00)			
08:00	Meet at lobby (8:00)				Transport by bus			Transport by bus	Lobby (8:30)		
	Briefing at Embassy (8:15-9:00)		Meet at lobby (8:30)				Transport by bus	Transport by bus	Transport by bus		
09:00		Transport	Transport		National Institute of Radiological Sciences (9:30-11:30) Fukushima Red Cross Hospital (10:00-12:00)	Lobby (9:30)	Minami Soma Decontamination Laboratory (9:30-12:00)	Ishinomaki Red Cross Hospital (9:00-11:00)	Date City Decontamination Base by MOE (9:30-11:50)		
10:00		Tokyo Fire Dept. Hyper Rescue Unit (10:00-11:45)	Meeting with Tokyo Medical and Dental University (9:30-11:00)			Fukushima Red Cross Hospital (10:00-12:00)					
	Transport										
11:00	MHLW International Affairs Division (11:00-12:00)		Transport					INJM, displaced residents (11:30-12:30)			
12:00		Transport			Transport by bus				Transport		
	Transport										
12:30-13:30	Lunch		Lunch		Lunch on train	Lunch	Lunch on bus	Lunch on bus	Lunch		

13:00			MHLW Health Policy Bureau (13:00-14:00)				JA Souma and Forestry Association (13:00-16:30)		Transport	
	Briefing by Cabinet Office FDMA and US Embassy (14:00-17:30)			Ministry of Env (13:30-15:00)	Transport to Fukushima by Yamabiko 63 (13:40-15:11)			Fukushima Medical Univ (14:00-16:00)	Transport back to Sendai by bus	Fukushima Saisei no Kai (14:00-18:00)
14:00										
15:00										
			Stem Cell Experts @ Toranomon Hospital (16:00-18:00)	Ministry of Agriculture (15:30-17:00)	Fukushima Prefectural Government (16:00-17:30)		Transport back to Fukushima by bus	Tohoku Medical Mega Bank (15:30-17:30)		
16:00										
17:00										
	Transport			Transport		Trans. to Sendai on Yamabiko 67 (17:12-17:33)				
18:00				Investigation Committee (17:45)	Informal debrief. (30 min)				Transport to Fukushima by bus	
19:00							Transport back to Tokyo on Hayata 112 (18:41-20:24)	Transport back to Fukushima by bus		
20:00								Transport back to Tokyo on Yamabiko 64 (20:27-10:00)		
	Dinner meeting with Professor Hayano, Tokyo University and Dr Stefan Noreén		Embassy reception		Dinner with Dr Tsubokura, University of Tokyo Hospital / Minami Soma City Hospital	Dinner on train	Dinner with Iitate-mura Mayor	Dinner on train	Dinner on train	

Orange: gemensamt program Blått: det medicinska spåret Grönt: saneringsspåret

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